ICAO

Doc 10104

Manual on Flight Recorder System Maintenance (FRSM)

First Edition, 2020

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

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AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

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FOREWORD

Some States' accident investigation authorities regularly experience problems during the download of flight data recorders (FDRs) due to the unavailability of data frame information. Similarly, challenges were encountered due to cockpit voice recorders (CVRs) that were not operational during accidents and incidents. Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*, 6.3.5.3 requires that operational checks and evaluations of recordings from flight recorder systems be conducted to ensure the continued serviceability of the recorders. The procedures for these checks and evaluations, found in Appendix 8 of Annex 6, Part I and similar provisions in Part II — *International General Aviation — Aeroplanes* and Part III — *International Operations — Helicopters*, are not sufficient and further guidance material is needed. In addition, the procedures may not be translated into equipment maintenance requirements produced by the manufacturers. Similar concerns were raised during the Accident Investigation and Prevention (AIG) Divisional Meeting (2008) (AIG/08) which resulted in Recommendation 2/4 for the Air Navigation Commission to note the concerns raised by AIG/08. Relevant guidance material exists in some States such as the United Kingdom CAP 731 document and similar recorder maintenance documents from Australia, France, United States, European Union Aviation Safety Agency (EASA) and others. However, it was deemed beneficial to have such guidance material in an ICAO document available to States and hence this document was developed by the Flight Recorder Specific Working Group of the Flight Operations Panel.

Comments on this manual are appreciated, particularly with respect to its application and usefulness. These comments will be taken into consideration in the preparation of subsequent editions. Comments concerning this manual should be addressed to:

The Secretary General
International Civil Aviation Organization
999 Robert-Bourassa Boulevard
Montréal, Quebec, Canada H3C 5H7

GLOSSARY

DEFINITIONS

Analogue data. Data transferred between line replaceable units (LRUs) via a varying signal on dedicated circuits.

Corrupted data. Any data item or record which has been altered in a way other than the one intended by design.

Data download. The extraction of binary data from a flight recorder.

Data conversion. The conversion of binary FDR data to a scaled value.

Digital data. Data transferred between LRUs via digital data buses such as ARINC 429.

Drop out. A loss of synchronization, corrupted bit or data word that was recorded and cannot be correctly recovered by the data recovery and analysis system.

Engineering unit (EU). Scaled value relating to the data source, e.g. altitude scaled to feet, airspeed scaled to knots.

Flight data analysis. A process of analysing recorded flight data in order to improve the safety of flight operations.

Flight recorder data download. Means of copying the digital data stored in the crash-protected memory module for replay at a later time.

Flight recorder data retrieval. Retrieval of data from the recording medium for the task of presenting the data for analysis purposes.

Flight recorder readout. An analysis of the recorded data from a flight recorder.

Flight recorder replay. The act of reconstructing the recorded situations/scenarios.

Functional check. A functional check is a quantitative check to determine if one or more functions of an item perform within specified limits. When applied to an FDR parameter, the functional check determines that the recorded parameter is within the limits (range, accuracy, sampling rate and resolution) specified in the operating rule. The maintenance functional check should exercise the recording system from the sensor or transducer to check the range, accuracy, resolution and sampling rate of the recorded data.

Intelligibility. A measure of the speech contained in the cockpit voice/cockpit audio recording to determine how comprehensible, or able to be understood, the spoken content is.

Maintenance[1]. The performance of tasks required to ensure the continuing airworthiness of an aircraft, including any one or combination of overhaul, inspection, replacement, defect rectification and the embodiment of a modification or repair.

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1. Applicable until 4 November 2020.

Maintenance[2]. The performance of tasks on an aircraft, engine, propeller or associated part required to ensure the continuing airworthiness of an aircraft, engine, propeller or associated part including any one or combination of overhaul, inspection, replacement, defect rectification and the embodiment of a modification or repair.

Maintenance organization's procedures manual[1]. A document endorsed by the head of the maintenance organization which details the maintenance organization's structure and management responsibilities, scope of work, description of facilities, maintenance procedures and quality assurance or inspection systems.

Maintenance programme. A document which describes the specific scheduled maintenance tasks and their frequency of completion and related procedures, such as a reliability programme, necessary for the safe operation of those aircraft to which it applies.

Operational check. An operational check is a failure-finding task to determine if a parameter is being recorded and does not determine if the item is performing within specified limits. When applied to an FDR, the operational check determines that the FDR is active and recording each parameter value within the normal operating range of the sensor. The operational check must also verify each electrical interface to the FDR. A check to determine the reasonableness and quality of the data being recorded is considered an operational check.

Parameter. The aircraft system or motion required to be recorded, e.g. for control surface, flap position; and for aircraft velocity, airspeed.

Phases of flight. A phase of flight refers to a period within a flight. In the case of a manned aircraft, a flight begins when any person boards the aircraft with the intention of flight and continues until such time as all such persons have disembarked. In the case of an unmanned aircraft, a flight begins at the time the aircraft is ready to move with the purpose of flight and continues until such time it comes to rest at the end of the flight and the primary propulsion system is shut down. An aircraft may be in any one of the following phases of flight:

a) standing;

b) pushback/towing;

c) taxi;

d) take-off;

e) initial climb;

f) en-route;

g) manoeuvring;

h) approach;

i) landing;

j) emergency descent; and/or

k) uncontrolled descent.

Quality. Refers to the amount of data that cannot be recovered or is corrupted.

2. Applicable as of 5 November 2020.

Reasonableness. The term reasonableness refers to the assessment of recorded parameter values to detect gross errors against expected magnitudes, directions, rates of change and correlation with other parameters.

Simulation. The use of a laboratory-installed system of avionic components ('test bench') representative of the aircraft in which the FDR system is to be certified. The test bench may be controlled by a computer-based system including analogue and discrete inputs to create specific operating conditions, such as 90° pitch up, or other conditions that cannot be tested in flight or are difficult to test on the aircraft. The test bench should be configured such that the computer or analogue inputs to the system drive the instruments and displays in a way representative of the aircraft. All avionic components installed in the test bench should be either of production standard or representative of the final production configuration.

Stimulation. The use of test equipment, traceable to a known Standard, to induce aircraft systems to produce a specific result.

Test. A means of demonstrating compliance, using a test aircraft in a configuration representative of the configuration to be certified, in a ground and/or flight environment.

Validity. The term validity refers to the assessment of recorded data to discern whether it accurately represents the events occurring during a flight.

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ACRONYMS AND ABBREVIATIONS

A/C	Air conditioning
AC	Alternating current
ACAS	Airborne collision avoidance system
ADFR	Automatic deployable flight recorder
ADRS	Aircraft data recording system
ADS-B	Automatic dependent surveillance — broadcast
ADS-C	Automatic dependent surveillance — contract
AFCS	Automatic flight control system
AFN	ATS facilities notification
AIR	Airborne image recorder
AIRS	Airborne image recording system
ARINC	Aeronautical Radio Inc.
ASR	Air Safety Report
ATC	Air traffic control
ATN	Aeronautical telecommunication network
ATS	Air traffic service
BCD	Binary-coded decimal
BITE	Built-in test equipment
CAM	Cockpit area microphone
CARS	Cockpit audio recording system
CM	Context management
COMBI	Combined flight recorder
CPDLC	Controller-pilot data link communications
CSMU	Crash survivable memory unit
CVR	Cockpit voice recorder
D-ATIS	Data link-automatic terminal information service
DC	Direct current
DCL	Departure clearance
DFDAU	Digital flight data acquisition unit
DFL	Data frame layout
DLR	Data link recorder
DLRS	Data link recording system
D-METAR	Data link aviation weather report service
D-NOTAM	Digital notice to airmen
EAFR	Enhanced airborne flight recorder
EASA	European Union Aviation Safety Agency
ELT	Emergency locator transmitter
EMI	Electromagnetic interference
EPR	Engine pressure ratio
ESD	Electrostatic discharge
EU	European Union or engineering unit
EUROCAE	European Organisation for Civil Aviation Equipment
FANS	Future air navigation systems
FCMIR	Flight crew-machine interface recordings
FDA	Flight data analysis
FDAF	Flight data acquisition function

FDAP	Flight data analysis programme
FDAPM	*Manual on Flight Data Analysis Programmes (FDAP)*
FDAU	Flight data acquisition unit
FDIMU	Flight data interface management unit
FDIU	Flight data interface unit
FDM	Flight data monitoring
FDR	Flight data recorder
FOQA	Flight operations quality assurance
FRED	Flight recorder electronic documentation
GPWS	Ground proximity warning system
GSM	Global system for mobile communications standard
ICAO	International Civil Aviation Organization
LLDC	Low level direct current
LOSA	Line operations safety audit
LRU	Line replaceable unit
LSB	Least significant bit
MASPS	Minimum Aviation System Performance Specification
MEL	Minimum equipment list
MMEL	Master minimum equipment list
MSB	Most significant bit
NCD	Non-computed data
OCL	Oceanic clearance
OEM	Original equipment manufacturer
QAR	Quick Access Recorder
RIPS	Recorder independent power supply
SARPs	Standards and Recommended Practices
SDCPS	Safety data collection and processing system
SMM	*Safety Management Manual*
SMS	Safety management system
SOP	Standard operating procedure
STC	Supplemental type certificate
TC	Type certificate
TCAS	Traffic alert and collision avoidance system
TSO	Technical Standard Order
WD	Word

PUBLICATIONS

International Civil Aviation Organization (ICAO)

Annex 6 — *Operation of Aircraft*
Part I — *International Commercial Air Transport — Aeroplanes*
Part II — *International General Aviation — Aeroplanes*
Part III — *International Operations — Helicopters*

Annex 10 — *Aeronautical Telecommunications*, Volume III — *Communication Systems*

Annex 13 — *Aircraft Accident and Incident Investigation*

Annex 19 — *Safety Management*

Manual on Flight Data Analysis Programmes (FDAP) (Doc 10000)

Manual on Location of Aircraft in Distress and Flight Recorder Data Recovery (Doc 10054)

Others

Australian Civil Aviation Safety Authority (http://www.casa.gov.au)
Advisory Circular AC 21-24 — *Flight recorder and underwater locating device maintenance*

United Kingdom Civil Aviation Authority (https://www.caa.co.uk/home/)
Civil Aviation Publication CAP 731 — *Approval, Operational Serviceability and Readout of Flight Data Recorder Systems and Cockpit Voice Recorders*

United States of America Federal Aviation Administration (http://www.faa.gov/)
Advisory Circular AC 20-141B — *Airworthiness and Operational Approval of Digital Flight Data Recorder Systems*

European Organization for Civil Aviation Equipment (EUROCAE) (http://www.eurocae.net)
ED-93 — *Minimum Aviation System Performance Specification for CNS/ATM Message Recording Systems*
ED-112A — *Minimum Operational Performance Specification for Crash Protected Airborne Systems*
ED-155 — *Minimum Operational Performance Specification for Lightweight Recording Systems*

Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (https://www.bea.aero/en/)
Guidance on CVR recording inspection — October 2018
Study on Detection of Audio Anomalies on CVR Recordings — September 2015
Flight Data Recorder Read-Out Technical and Regulatory Aspects — May 2005

European Union Aviation Safety Agency (http://www.easa.europa.eu/)
Certification Memorandum EASA CM-AS-001, *Quality of Recording of Cockpit Voice Recorders*
Safety Information Bulletin 2009-28R1, *Flight Data Recorder and Cockpit Voice Recorder Systems Serviceability*
Commission Regulation (EU) No 965/2012 of 5 October 2012

Aeronautical Radio Inc. (ARINC) 428, 429, 573, 647A, 717, 767

Federal Aviation Administration (FAA) AC 20-141B — *Airworthiness and Operational Approval of Digital Flight Data Recorder Systems*

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Chapter 1

INTRODUCTION

1.1 BACKGROUND

1.1.1 Flight recorders, or "black boxes", have become synonymous with aircraft accident and incident investigations. The recovery of the flight recorder and subsequent retrieval and analysis of the valuable information stored within the crash-protected memory is widely recognized both by the aviation industry and by the general public. Having valid and useful information available not only contributes to effective accident or incident investigation but is an essential part of flight monitoring systems to improve operational efficiency. It also provides performance information of airframes and engines that can assist in continuing airworthiness.

1.1.2 However, the recording unit is not the sole component that contributes to the logging of useful information. A flight recorder system is made up of many components and interconnections with aircraft systems and dedicated sensors. Problems can result from inadequate documentation and testing during airframe integration and consideration for continued serviceability of the flight recorder systems.

1.1.3 Accident and incident investigators have documented many instances where a recording unit was functioning but was recording corrupted information from faulty sensors. Also, poor or non-existent documents detailing the flight recorder system and recorded information have delayed or prevented the recovery of useful recorded information and, therefore, obstructed investigations and the development of safety recommendations.

1.1.4 Although a considerable amount of information and guidance material is available from a wide variety of sources, it is fragmented. Recurring issues indicate there is no consistent international guidance material relating to the maintenance of flight recorder systems applied throughout the world.

1.1.5 The importance of consistent guidance material, readily available to all States, is highlighted by the truly international operation of aircraft and their associated safety systems. It is not unusual for an aircraft to be registered and operated in one State while the flight recorder maintenance programme for that aircraft is performed on the other side of the world.

1.1.6 To assist States with the development of effective flight recorder maintenance programmes, this manual:

a) collates current flight recorder material;

b) contains a list of reference material; and

c) describes methods of maintenance ensuring the proper performance of the flight recorder system.

1.1.7 This manual is addressed to States providing oversight to air operators as well as air operators performing commercial air transport operations with aeroplanes and helicopters, and organizations performing flight recorder maintenance. It will be revised as new technology and recording systems are implemented.

1.2 OBJECTIVES AND SCOPE

1.2.1 The objective of this manual is to provide:

a) a description of flight recorder systems;

b) a source of relevant guidance material relating to the maintenance of flight recorders systems; and

c) guidance to assist in the implementation of ICAO Standards and Recommended Practices (SARPs) and other International Standards regarding flight recorder system maintenance.

1.2.2 The scope of this manual is to:

a) provide an overview of current guidance material and Standards regarding flight recorder systems;

b) collate flight recorder system maintenance material; and

c) present guidance material that is concise and relevant in a single document.

1.3 FLIGHT RECORDER SYSTEM EXPERIENCE

1.3.1 Accident investigation authorities have identified recurring issues with flight data recorder (FDR) and cockpit voice recorder (CVR) systems. However, experience of such recurring issues with flight crew-machine interface recordings and data link recordings is limited. Examples of issues identified include (more details in respective chapters):

a) **FDR/Aircraft data recording system (ADRS):**

1) incomplete documentation of system fit (where components are located in the airframe and signal sources);

2) deficient parameter information (data frame layout and conversion from counts to engineering units);

3) input signals that are not compatible with recording system (amplitude of parameter signal is greater than recorder capabilities);

4) system continued serviceability not defined (published maintenance cycle based upon recording unit maintenance interval);

5) system calibration not specified or when specified, not performed to the required Standard; and

6) invalid recorder parameters (sensor unserviceable or providing unusable information);

b) **CVR/Cockpit audio recording system (CARS):**

1) incomplete documentation of system fit (where components are located in the airframe and signal sources);

2) input signals that are not compatible with recording system (dynamic range of microphones is not compatible with recorder input);

3) incorrect balance between radio and intercom inputs;

4) system continued serviceability not defined (published maintenance cycle based upon recording unit maintenance interval); and

5) daily and annual serviceability checks, where specified, not performed or inadequate;

c) **Airborne image recorder (AIR)/Airborne image recording system (AIRS):**

1) at the time of inception of this manual, flight crew-machine interface recording was not widely utilized;

2) experience gained has been positive with good quality images recovered and very little experience related to in service difficulties; and

3) the guidance material relating to image recorder maintenance references the EUROCAE ED-112A Specifications;

d) **Data link recorder (DLR)/Data link recording system (DLRS):**

1) at the time of inception of this manual, data link recordings had been utilized for some time although Annex 6 — *Operation of Aircraft* provisions for data link recordings only became applicable on 1 January 2016. Data link recordings are usually not made on a separate recorder but on flight data recorders. No data link recordings are currently made on light weight recorders;

2) experience gained is limited, but has been positive in cases where the data link information was recorded; and

3) the guidance material relating to data link recorder maintenance references the EUROCAE ED-112A Specifications.

1.4 FLIGHT RECORDER SYSTEM MAINTENANCE

1.4.1 Maintenance is a series of defined tasks (checks) performed by qualified individuals to ensure the continuing airworthiness (determine the correct function) of an aircraft, engine, propeller or the associated parts (sub-systems). Where maintenance action detects an incorrect function, the maintenance system will provide an output that alerts the appropriate entities to perform correcting actions.

1.4.2 A maintenance system or programme should be in place for each flight recorder system. The maintenance programme should be reviewed on a regular basis; especially when a new aircraft type is added to the fleet, a change is made to flight recorder equipment, both airborne and ground-based.

1.4.3 A maintenance programme should include administrative procedures for scheduling, accomplishing, and recording maintenance actions on the flight recorder system. The maintenance programme should identify inspection items, establish intervals for maintenance and provide the details of the proposed methods and procedures.

1.4.4 The maintenance programme of the flight recorders should also make reference to ancillary components for example underwater locating devices and that these components need to be scheduled for maintenance as required by the manufacturer of such components.

1.4.5 Responsibilities of participants developing and assuring the integrity of a maintenance programme are:

a) ICAO — SARPs and guidance material (defines safety system);

b) States — legislation and surveillance (monitoring of safety system);

c) Operators — resources, training and equipment, monitoring of contact input to daily operations (implementation of safety system);

d) Contractors — output meets Operators' and States' requirements and Standards; and

e) Flight recorder system installers (type certificate (TC) or supplemental type certificate (STC) holder) — have the knowledge of the flight recorder system installation and of necessary tasks to maintain all components of the flight recorder system serviceable.

1.5 ICAO SARPs REGARDING FLIGHT RECORDER MAINTENANCE

1.5.1 Annex 6, Part I — *International Commercial Air Transport — Aeroplanes*, Part II — *International General Aviation — Aeroplanes* and Part III — *International Operations — Helicopters*, contain the provisions for continued serviceability of flight recorder systems in the following sections of the three parts of Annex 6:

a) Part I, Amendment 43, section 6.3.5.3[1], refers to Appendix 8 for continued serviceability;

b) Part II, Amendment 36, section 2.4.16.4.4[2], refers to Appendix 2.3 for continued serviceability; and

c) Part III, Amendment 22, section 4.7.4.3[3], refers to Appendix 4 for continued serviceability.

Note.— Any deficiencies found should be corrected in accordance with the appropriate aircraft maintenance manual (AMM), component maintenance manual (CMM) or the supplemental type certificate (STC) holder's continued airworthiness instructions.

1. Annex 6, Part I, Amendment 43, applicable on 8 November 2018.
2. Annex 6, Part II, Amendment 36, applicable on 8 November 2018.
3. Annex 6, Part III, Amendment 22, applicable on 8 November 2018.

Chapter 2

GENERAL REQUIREMENTS FOR FLIGHT RECORDER SYSTEM MAINTENANCE FACILITIES

2.1 INTRODUCTION

2.1.1 Operators and/or contractors seeking to undertake flight recorder maintenance or to implement a flight recorder maintenance programme will need to take the following information into consideration when establishing facilities and developing procedures to perform flight recorder system maintenance. These maintenance procedures should emphasize the need to preserve the recording following an accident or incident.

2.1.2 These include:

a) facilities or premises suitable for performing flight recorder system maintenance (including all components of the flight recorder system, such as dedicated sensors and transducers, attached underwater locating device (ULD) or emergency locator transmitter (ELT), means to stop the recorder within 10 minutes of a crash impact, acquisition unit in the case of an FDR, recorder independent power supply (RIPS) in the case of a CVR, etc.);

b) software and hardware specific to the readout of flight recorders;

c) procedures specific to the readout of flight recorders;

d) provision and control of associated replay support documentation;

e) staff training and competence; and

f) procedures specific to the documentation of the results of flight recorder readout(s)/replays.

Note 1.— An operator who has contracted this task to a separate organization must detail in their system of maintenance who carries out the readout and how they control and audit that organization.

Note 2.— In cases where the term readout is used, this also includes CVR, AIR and DLR replay and recording systems that perform the same function, e.g. light weight recorders.

2.2 FACILITIES OR PREMISES SUITABLE FOR PERFORMING FLIGHT RECORDER MAINTENANCE

2.2.1 Flight recorder system maintenance should be considered equivalent to avionics systems and/or component maintenance. Therefore, premises used to support flight recorder system maintenance should be of an equivalent standard of equipage to support sensitive electronic equipment.

Note.— The location and type of facilities needed to perform flight recorder maintenance, especially CVR, AIR, and lightweight equivalents, may need special consideration. This is due to the need for a quiet and secure area to allow accurate assessment of audio. Also, the information contained in CVR and AIR recordings is sensitive and afforded the privilege to appear in ICAO Annexes and some State legislations.

2.2.2 Highlighted in Annex 6, Part I, Chapter 3, section 3.3.4 (applicable on 7 November 2019) is the following: "States shall not allow the use of recordings or transcripts of CVR, CARS, Class A AIR and Class A AIRS for purposes other than the investigation of an accident or incident as per Annex 13, except where the recordings or transcripts are", among other reasons, used for inspection of flight recorder systems as provided in Annex 6, Part I, Appendix 8, Section 7 and equivalent provisions in Parts II and III.

2.3 HARDWARE AND SOFTWARE SPECIFIC TO THE READOUT OF FLIGHT RECORDERS

2.3.1 Flight recorder hardware and software is needed to retrieve the data from the recording medium and convert the data into a suitable format for readout.

2.3.2 Flight recorder download hardware and software may be sourced from the specific flight recorder manufacturer. Most flight recorder manufacturers also supply readout software. However, it is becoming increasingly common for other companies to market flight recorder download and/or readout hardware and software.

2.3.3 All replay facilities should have procedures in place to address the issues related to control of the hardware and software used for flight recorder readouts.

2.3.4 The procedures should cover:

a) that the hardware and software is correct for the flight recorder system being examined;

b) assessing proposed updates for current hardware and software;

c) maintaining any hardware and software used for replaying flight recorders, including documenting system changes;

d) the processes for backing up any necessary files; and

e) the considerations related to determining the need for new hardware and software.

2.4 PROCEDURES SPECIFIC TO THE READOUT OF FLIGHT RECORDERS

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

2.4.2 The procedures should cover:

a) how to establish that the correct replay equipment is being used;

b) how to connect the replay and readout equipment;

c) how to operate the replay and readout equipment; and

d) how to detect replay/readout equipment failures and initiate rectification.

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

2.4.4 The procedures should cover:

a) checks for the existence of basic information, an example of which is examining the downloaded data file to ascertain if usable data is contained within the file, the duration of the recovered data and whether it meets the regulatory minimum required;

b) checks for assessing the information provided relating to the sample flight to determine what data can or cannot be gathered. An example could be related to the recording of an individual FDR parameter (i.e. if radio altitude data is not provided, the radio altitude parameter cannot be assessed);

c) the way in which this data should be assessed to determine the possible flight recorder readout report detail (i.e. is there sufficient information to assess the accuracy of the parameters or is it only possible to determine “shows” and “no shows”?); and

d) the generation of the “report limitations” section of the FDR Report.

2.4.5 **Procedures for replay support documentation**

2.4.5.1 All replay facilities should have procedures in place covering the revision control of all flight recorder maintenance programme documents, including regulatory, technical and background documents.

2.4.5.2 The procedures should cover:

a) a list of all documents that are used in the assessment process, examples of relevant documents may include service history of the component, or a document showing the FDR recorded data format such as a FRED file;

b) a list of the different types of media being used (e.g. CD, magnetic tape, etc.);

c) the method of configuration control being used;

d) the means used to store them (including any environmental considerations);

e) the location of all configured documents;

f) the means of accessing those documents;

g) the backup procedures;

h) full software and hardware descriptions and control of past versions, etc.; and

i) security and control of access to flight recorder data.

2.4.5.3 These procedures should also cover the provision and configuration control used to correlate specific documents to specific aircraft and flight recorders. Documents relating to a specific system may be needed to validate the maintenance of hardware and software. The same procedures should be applied to any other supporting data necessary for a flight recorder readout.

Note.— Further guidance applicable to individual flight recorder systems may be found in the relevant section.

2.4.5.4 An example of FDR data conversion documentation is included below. Information necessary to convert the FDR download file into engineering units can be found in:

a) data frame layout documents; and

b) engineering conversion documents.

Note 1.— Data frame layout (DFL) documents and engineering conversion documents can be in the flight recorder electronic documentation (FRED) format (ARINC 647A).

Note 2.— In cases where the recorder has the facility to store the FRED file within the crash survivable memory unit (CSMU), the operator should ensure that the FRED file is uploaded onto the recorder.

2.5 PROCEDURES FOR STAFF TRAINING

2.5.1 All replay facilities should have procedures in place to address staff training. Training procedures should cover:

a) the basic knowledge required to replay FDRs or ADRS. As a minimum this should include:

   1) understanding of FDR or ADRS hardware design, maintenance and replay;

   2) assessing the accuracy/currency of the associated DFLs, etc.;

   3) understanding of the integration of the DFL of the data recovery and analysis systems; and

   4) assessing the aircraft information provided;

b) the basic knowledge required to replay CVRs or CARS. As a minimum this should include:

   1) understanding of CVR or CARS hardware design, maintenance and replay;

   2) assessing the quality of the recorded audio when replayed; and

   3) understanding the file types available as recorded on the CVR or the CARS;

c) the basic knowledge required to replay AIRs or AIRS. As a minimum this should include:

   1) understanding of AIR or AIRS hardware design, maintenance and replay;

   2) assessing the quality of the recorded images when replayed; and

   3) understanding of the file types available as recorded on the AIR or AIRS;

d) the basic knowledge required to replay DLRs or DLRS. As a minimum this should include:

   1) understanding of DLR or DLRS hardware design, maintenance and replay;

2) assessing the accuracy/currency of the associated data link messages;

3) understanding of the data link recovery and analysis systems; and

4) assessing the data link messages in relation to aircraft information provided;

e) the interpretation, relevance and application of:

1) ICAO SARPs and guidance material;

2) legislation enacted by States:

3) flight recorder system Standards; and

4) flight recorder manufacturer and aircraft integration information;

f) using the necessary hardware and software tools;

g) interpreting the output of those tools;

h) drafting replay reports;

i) the requirement to update training (e.g. new recorders);

j) the means of staff training, an example may be on the job training or participation in a formal course; and

k) the method of keeping and updating staff training records.

2.6 FLIGHT RECORDER SYSTEM READOUT REPORT

2.6.1 A report that is comprehensive and clearly indicates the results of the readout and assessment is essential to mutually document the results of the flight recorder readout and, if necessary, activate and inform subsequent flight recorder component or system troubleshooting and repair that may be required.

2.6.2 The content of the report should detail the scope of work to be performed, the readout and analysis that was performed and any limitations in the readout process that may affect the determination of the integrity of the data readout.

2.6.2.1 For example, if the purpose of the readout is to confirm the correct presence of a FDR system discrete, accuracy of a sensor, or comply with a maintenance programme requirement to verify that parameters are being accurately recorded, the report should indicate which parameters were examined and any limitations in the analysis of the recorded information.

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Chapter 3

FLIGHT DATA RECORDER SYSTEM MAINTENANCE

3.1 FLIGHT DATA RECORDER SYSTEM STANDARDS

3.1.1 Minimum performance for flight data recorder systems and airborne data recording systems are contained in Annex 6 and reference EUROCAE documents ED-112A and ED-155, respectively.

3.1.2 However, an earlier version of these specifications may be applicable and will be dependent upon the date the FDR system was certificated.

3.1.3 Other documentation with reference to flight recorder maintenance is available from the Australian Civil Aviation Safety Authority, United Kingdom Civil Aviation Authority, European Commission Regulation and others, as referred to in the reference publications section of this manual.

3.1.4 The provisions to fit a FDR system or airborne data recording system is contained in Annex 6, Parts I, II and III.

3.1.5 Each part of Annex 6 specifies inspection intervals (refer to Table 3-1 below and to Annex 6 for the original requirements).

Table 3-1. FDR/ADRS maintenance intervals

Interval	*Action*
Prior to first flight of the day	Activate (if required) and monitor recorder system self-test or built-in test function.
One year	Inspection of recording consisting of checks in accordance with Annex 6.
Two years	Inspection of recording that has demonstrated a high integrity of serviceability and self-monitoring, consisting of checks in accordance with Annex 6. A two-year time period is subject to approval by the State national airworthiness authority.
As specified by sensor manufacturer or, if unspecified, two years	Calibration of airspeed and altitude sensors dedicated to the FDR system.
As specified by sensor manufacturer or, if unspecified, five years	Calibration of sensors dedicated to the FDR system and not checked by other means.

3.2 FLIGHT DATA RECORDER SYSTEM MAINTENANCE PROGRAMME

3.2.1 The maintenance programme for the flight recorder system should be established by the FDR system installer (TC or STC holder) and it should be reviewed on a regular basis and as described in section 1.5.

3.2.2 A flight data recorder maintenance programme should include the following:

a) ***Description of the FDR system.*** Typically the system description should include the make and model or part number of the FDR and each data acquisition system. It should include a listing of each parameter recorded (reference to a manufacturers report or technical document would suffice) and should identify any sensors installed specifically for the purpose of sensing FDR data (this should be correlated against any item identified by the aircraft manufacturer's maintenance programme). The system description should identify interfaces to other installed equipment and systems.

b) ***Scheduled maintenance tasks.*** Where appropriate, describe the scheduled maintenance tasks for each component of the FDR system. Whenever possible, routine maintenance of the recording system should be timed to coincide with periods of scheduled maintenance of the aircraft. Careful consideration should be made to minimize the requirement for the aircraft to operate should the recording equipment need to be removed.

c) ***Description of the FDR data processing system.*** The system description should identify interfaces to other installed equipment and systems. The data decoding/conversion configuration for an individual FDR data file processed should be recorded. The relevant data frame applicable to the FDR system is the responsibility of the operator to hold and maintain. The parameters specified will be dependent upon the date the FDR system was certificated. For an example of an ARINC 717 data frame refer to Appendix C to Chapter 3 and for examples of ARINC 767 replay support documents refer to Appendix D to Chapter 3.

d) Annex 6 specifies recording system inspections. It determines that the calibration of the FDR system:

   1) for those parameters which have sensors dedicated only to the FDR and are not checked by other means, recalibration shall be carried out at least every five years or in accordance with the recommendations of the sensor manufacturer to determine any discrepancies in the engineering conversion routines for the mandatory parameters and to ensure that parameters are being recorded within the calibration tolerances; and

   2) when the parameters of altitude and airspeed are provided by sensors that are dedicated to the FDR system, there shall be a recalibration performed as recommended by the sensor manufacturer, or at least every two years.

e) Recording system inspections may be performed as an operational or functional check, as described below:

   1) ***An operational check*** that provides sufficient information to assess the reasonableness and quality of the recorded values. The operator should use a periodic readout or data extraction of the flight recorder to accomplish this requirement; and

   2) ***A functional check*** that provides sufficient information to assess the range, accuracy and recording interval for each parameter fitted to the aircraft. This information will then be used to confirm the correct operation of the data conversion algorithms utilized in the data recovery and analysis system.

f) ***Retention of FDR system documentation.*** A procedure for the retention of FDR correlation documents applicable to each individual aircraft. Also, retention of any additional documents needed to enable accurate conversion of recorded values to their corresponding engineering units. These documents should also be readily available so that they can be provided to the relevant State accident investigation authority after an accident or a reportable occurrence.

g) ***Procedures for updating the correlation and data conversion documentation for each individual aircraft.*** These procedures should also provide for an update upon modification of a flight data recording system.

h) ***A report detailing the results of the last annual inspection shall be retained.*** The FDR information relating to the last two operational and last two functional checks should be retained as part of the aircraft maintenance records. Operators may retain the actual FDR data and corresponding data conversion algorithms, used at the time the FDR data was collected, in electronic format. However, the operator should be able to print out the data or otherwise provide it in a readable format at the request of investigators or the State National Airworthiness Authority. If the operator does not have the capability to download or retain the data in electronic format, a tabular computer printout(s) is acceptable. Provide for retention of these records until they are replaced by records from a subsequent check.

3.3 DESCRIPTION OF FLIGHT DATA RECORDER SYSTEM

3.3.1 The system description must include the following (refer to the template in Appendix A of Chapter 3 which may be adapted for either aeroplanes or helicopters):

a) the make and the model or part number of the FDR, flight data acquisition unit (FDAU), or digital FDAU (DFDAU) (or equivalent function);

b) a listing of each parameter recorded;

c) documentation which shows the correlation data for each parameter;

d) identification of all sensors installed specifically for the purpose of sensing required data. Include the manufacturer and part number of the sensor;

e) identification of sensors not dedicated exclusively to the FDRS. Include the sensor source and the associated digital data bus source;

f) identification of pneumatic inputs directly connected to the FDRS for pitot-static information;

g) identification of components of the FDRS that meet Technical Standard Order (TSO) standards including the TSO number and any authorized deviations from the TSO requirements;

h) description of structural alterations associated with the installation;

i) a wiring diagram and system schematic. Describe all dedicated wires. Identify all interfaces to other installed equipment and systems; and

j) identification of parameters recorded from data buses. They must include source data bus system, word, and label information.

Note.— Acceptable guidelines for documentation of FDR data content and format are contained in FAA AC 20-141B, Appendix 1 and in the ARINC FRED Specification (ARINC 647A). These data format guidelines provide the information necessary to decode the FDR raw data stream. The information can be contained in hardcopy document or electronic format.

3.4 FDR SYSTEM SERVICEABILITY AND READOUT

3.4.1 The flight data recorder readout may be carried out 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 to an external organization which is also required to have specific procedures detailing how an FDR readout will be performed and controlled.

3.4.2 The sections below provide guidance regarding specific procedures required to perform the flight recorder system maintenance task and the responsibilities of the participants. However, under most State legislation, 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 complete recording stored by the FDR should be downloaded and representative flight analysed to evaluate the continued serviceability of the FDR system.

Note.— The guidance on the calibration of the FDR system referred to in Annex 6, Part I, Appendix 8, and equivalent provisions in Annex 6, Parts II and III, has caused some confusion among industry. The word "calibration" is a term that is used for analogue inputs to FDRs. Some of the analogue sensors providing data to the recorders could drift out of tolerance and would require re-calibration. The TC holder should be consulted in the event of any doubt.

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

a) 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; and/or

b) a combination of scheduled maintenance tasks and validation of recorded data.

3.5 SELECTING A REPRESENTATIVE FLIGHT TO PERFORM AN OPERATIONAL CHECK

3.5.1 An operational check is a task which determines that the flight recorder system is fulfilling its intended purpose. This task does not require quantitative tolerances as it is a failure-finding task. When applied to an FDR, the operational check determines that the FDR is active for the nominal recording duration, typically 25 hours, and recording each parameter value within the normal operating range of the sensor. The operational check must also verify that the data have been consistently recorded in the last 25 hours and each electrical interface to the FDR. A check to determine the reasonableness and quality of the data being recorded is considered an operational check.

3.5.2 Reasonableness is an off-aeroplane review of recorded data to assess the overall health of the recorded system parameters. The recorded parameter values are assessed against expected magnitude, direction and rates of change. For further information, see the United States, Federal Aviation Administration (FAA) AC 20-141B.

3.6 DATA ANALYSIS/FLIGHT SEGMENT SELECTION

3.6.1 Parameter check

3.6.1.1 ***Failed parameters.*** The analyst should examine the extracted data to determine if parameters (e.g. flight controls, flight control surface positions and heading) that normally vary in flight are indeed varying and do so within expected ranges. Pegged or unmoving parameter values are indications of an inoperative sensor or other failure. Accelerometers tend to fail in the "pegged" position. If the accelerometer trace is unmoving throughout all segments of flight, check to see if it indicates maximum or minimum acceleration. An accelerometer failure indicating a mid-point value is uncommon.

3.6.1.2 ***Correlation to other parameters.*** The reasonableness check should include a check of the correlation between parameters that depend upon each other. For example: If *roll* increases, a turn is indicated and *heading* should begin to change soon after the increase is detected. Also, *aileron position* and *control wheel position* should have changed before the *roll* increase. One may even note a variation in *lateral acceleration*.

3.6.1.3 The data to be used by the analyst should be extracted from take-off, cruise and landing phases of flight. The take-off and landing segments of flight provide the analyst an opportunity to observe data that is changing as the aircraft climbs, descends, accelerates, decelerates, and banks or turns. During the cruise segment of a flight most parameters should remain reasonably steady. A lack of stability may reveal a fault in the recording system.

3.6.1.4 Table 3-2 is an example of a correlation between the first 20 mandatory parameters and is provided as an aid in preparing a reasonableness checklist. A check mark (✓) in a cell indicates that the parameter identified in the row and the parameter identified in the column are interdependent at some time during take-off and climb or approach and landing. Therefore, a change in value of one parameter may cause or be caused by a change in the value of the other.

3.7 TYPICAL LATERAL CONTROL SURFACE POSITION REASONABLENESS AND QUALITY CHECK

3.7.1 The following example shows how Table 3-2 may be used in developing a reasonableness checklist for each parameter. Actual operation of the recorded parameters may vary depending on the sensors installed and the aircraft systems that are monitored.

3.7.2 In Table 3-2, the column labelled "lateral control surface position" contains check marks in the rows labelled "heading", "roll attitude" and "roll control position". The lateral control surfaces are typically ailerons that are used in establishing the aircraft in a turn and returning the aircraft to straight flight from a turn. The lateral control surface position data may be checked along with the lateral control position data. These checks may be accomplished during the approach and landing segment:

a) examine the lateral control surface position trace for deviations during the initial approach segment. A large sustained deviation would normally indicate the aircraft turning onto final approach heading. Check that the lateral control position and roll attitude make a large change at the same time;

b) check to determine that the heading begins to change immediately after the lateral control surface position begins to change. The heading should continue to change after the lateral control surface position returns to the zero or null value. The heading data should begin to change at a lower rate when the lateral control surface position data moves in the opposite direction and after the lateral control position is again returned to zero or null value, the heading data should again be constant; and

c) check the lateral control surface position data to determine that there are no data dropouts and that there is no noise in the data. If dropouts or noise are detected, determine that they are within allowable values and that they would not be interpreted as an actual control surface position movement.

Table 3-2. 20-parameter correlation

Note.— The parameters are numbered as per Civil Aviation Order (CAO) 103.19, Appendix 1

	Time	Altitude	Airspeed	Heading	Vertical acceleration	Pitch attitude	Roll attitude	Manual mic keying	Engine thrust	Longitudinal acceleration	Pitch control position	Lateral control position	Yaw control position	Pitch control surface position	Lateral control surface position	Yaw control surface position	Lateral acceleration	Pitch trim surface position	Trailing edge flaps	Leading edge flaps slats	Thrust reverse position	Air ground sensing	Angle of attack
(1) Time	■																						
(2) Altitude		■	✓	✓	✓			✓	✓				✓			✓			✓	✓		✓	
(3) Airspeed		✓	■															✓	✓	✓	✓	✓	
(5) Heading		✓		■			✓					✓			✓								
(4) Vertical acceleration		✓			■	✓				✓	✓			✓			✓					✓	
(7) Pitch attitude					✓	■					✓			✓				✓					✓
(8) Roll attitude				✓			■								✓		✓						
(6) Press to transmit for every transceiver		✓						■															
(9) Thrust of each engine		✓							■												✓	✓	
(11) Longitudinal acceleration					✓					■							✓	✓	✓	✓	✓	✓	
(18) Pitch control position					✓	✓					■			✓				✓					✓
(19) Roll control position				✓			✓					■			✓								
(20) Yaw control position		✓											■			✓							
(18) Pitch control surface position					✓	✓					✓			■				✓					✓
(19) Roll control surface position				✓			✓					✓			■								
(20) Yaw control surface position		✓											✓			■							
(16) Lateral acceleration					✓		✓			✓							■						
(17) Pitch trim			✓			✓				✓				✓				■					
(10) Trailing edge flaps		✓	✓							✓									■	✓			
(14) Leading edge devices stowed/deployed		✓	✓							✓									✓	■			
(13) Thrust reverser stowed/deployed (each engine)			✓						✓	✓											■	✓	
(12) Undercarriage swat or tilt switch		✓	✓		✓				✓	✓											✓	■	
(15) Angle of attack						✓					✓			✓									■

3.8 ESTABLISHING LIMITATIONS OF THE READOUT

3.8.1 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 contracting FDR readout organization or operator performing the readout.

3.8.2 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.

3.8.3 General notes

3.8.3.1 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.

3.8.3.2 This misunderstanding has resulted in some FDR system faults remaining unresolved. Appropriate validation of the data provided, together with a clear statement of the limitations of the readout report, will help to minimize the chance of such dormant faults remaining undetected. The following guidelines may assist in establishing a better understanding between the replay organization and its customers.

3.8.3.3 A replay organization should have sufficient information about the aircraft and its modification status to enable them to make an accurate replay. Unless the replay organization 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.

3.8.3.4 Any parameters that are “no shows” or have unusual characteristics should be noted on the report. The replay organization 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 the responsibility of investigating any reported anomalies. That said, if a replay organization has sufficient experience to suggest possible meanings for the data, it 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. The operator should ensure that an assessment is conducted to confirm that the quantity and quality of all data recovered from the FDR are correct for the data rate of the system and the recorder part number concerned.

3.9 ESTABLISHING REVISION AND APPLICABILITY OF DFLs AND CONVERSION DATA

3.9.1 Responsibility

It is the responsibility of the FDR system installer (TC or STC holder) to provide the operator with a complete data frame layout (DFL) and accurate conversion data. It is the responsibility of the operator to maintain up-to-date details of the appropriate DFL and conversion data, together with their current revision status, provided as part of the TC/STC and Certificate of Airworthiness processes (see sections 2.4.5 and 3.4 for further guidance).

3.9.2 Purpose

The purpose of defining the revision status and applicability of 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.

3.10 REPLAYING THE FDR RECORDED DATA

3.10.1 Responsibility

This is the responsibility of the organization performing the readout.

3.10.2 Purpose

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

3.10.3 General notes

The organization 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 2). 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.

3.11 REPORTING THE FDR READOUT RESULTS

3.11.1 Responsibility

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

3.11.2 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 organization has identified.

3.11.3 General notes

There is no pre-defined layout or format for FDR readout reports, but the following information should be provided as a minimum (refer to the template in Appendix B to Chapter 3 which may be adapted for either aeroplanes or helicopters):

a) unique document identifier for the readout report;

b) aircraft registration;

c) aircraft serial number;

d) FDR part number;

e) FDR serial number;

f) data acquisition unit details;

g) date of replay;

h) issue status and reference of data frame layout document;

i) issue status and reference of other associated documents (e.g. information to convert to engineering units);

j) supplier of DFL and associated information;

k) parameters replayed;

l) “no shows”;

m) noted anomalies;

n) compliance with general FDR requirements, e.g. sampling rates;

o) how to interpret a 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”); and

p) download validation equipment used, i.e. part number, serial number, etc.

3.12 ASSESSMENT OF THE FDR READOUT RESULTS

3.12.1 Responsibility

This is the responsibility of the aircraft operator/owner.

3.12.2 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.

3.12.3 General notes

3.12.3.1 The aircraft operator/owner must carefully analyse the FDR readout making use of the FDR readout report to establish whether it contains any anomalies. If anomalies are found, the aircraft operator/owner must investigate them to determine their cause and take corrective action.

3.12.3.2 Where an operator needs to contract this task, it should be detailed in the system of maintenance or engineering manual and a contract established with the delegated organization. The operator, however, remains responsible for ensuring the task is carried out.

3.12.3.3 If an anomaly is detected, the necessary rectification work must be performed within the time period specified by the relevant master minimum equipment list (MMEL) or operational rule. Where a minimum equipment list (MEL) allowance is required, the MEL rectification interval starts when the FDR parameter(s) defects are identified.

3.13 RETENTION AND CONTROL OF FDR READOUT RESULTS

3.13.1 Responsibility

This is the responsibility of the aircraft operator/owner. The aircraft operator/owner is required to retain readout records/test reports in a manner and for a period acceptable to the State National Airworthiness Authority/National Competent Authority.

3.13.2 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.

3.13.3 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.

3.14 FLIGHT DATA RECORDER PRE-FLIGHT CHECK (DAILY)

Prior to the first flight of the day, the built-in test features of the FDR and FDAU shall be monitored either by manual and/or automatic means so as to detect a system failure.

3.15 FLIGHT DATA RECORDER OPERATIONAL CHECK

3.15.1 Operational check

An operational check is a failure-finding task to determine if a parameter is being recorded and does not determine if the item is performing within specified limits. When applied to an FDR, the operational check determines that the FDR is active and recording each parameter value within the normal operating range of the sensor. The operational check must also verify each electrical interface to the FDR. A check to determine the reasonableness and quality of the data being recorded is considered an operational check.

3.15.2 Operational or reasonableness and quality check

The operator must accomplish a reasonableness and quality check of the recorded flight data to ascertain that the data is being recorded correctly and that noise and data dropouts do not interfere with the ability to interpret the recorded data. The check may be performed using data that is in electronic format or hardcopy. If a hard copy printout is used, data traces should also be available. The check must be performed using data that has been extracted in EU because octal, binary-coded decimal (BCD), or hexadecimal coded data do not provide the analyst a clear understanding of how the parameters are varying and how they are correlated to each other.

3.15.3 Checklist

The analyst must use a checklist to confirm that all necessary checks have been accomplished. The checklist must refer the analyst to troubleshooting or repair procedures if a suspect parameter is identified.

3.15.4 Flight segment selection

The data to be used by the analyst should be extracted from both the take-off and the landing phases of flight. During the cruise segment of a flight the parameters remain steady and therefore movement of related parameters cannot be correlated. The take-off and landing segments of flight provide the analyst with an opportunity to observe data that is changing as the aircraft climbs, descends, accelerates, decelerates, and banks or turns. Furthermore, many parameters not exercised during the cruise segment are exercised during the take-off and landing segments. It is recommended the analyst conduct the review of parameters over several flight segments.

3.15.5 Sign conventions

Each aircraft has a pre-established sign convention for the direction of movement of its flight control surfaces. It is imperative the analyst be able to confirm proper direction of movement and not just verify movement. Therefore, the sign convention should be included in the checklist or the analyst should review the assigned sign conventions before beginning the check.

3.15.6 Failed parameters

3.15.6.1 The analyst should examine the extracted data to determine if parameters normally vary in flight, e.g. flight controls, flight control surface positions and heading are indeed varying. Values at their “maximum limit” or an unvarying value indicate an inoperative sensor or other failure. Accelerometers tend to fail at the “maximum limit” position. If the accelerometer trace is not moving during all segments of the flight, check to see if it indicates maximum or minimum acceleration. An accelerometer failure indicating a mid-point value is uncommon.

3.15.6.2 “Toggling”, or cycling from maximum to minimum value, characteristic recorded in the ARINC 717 data is a representation of ARINC 429 sign/system matrix (SSM) coding of non-computed data (NCD). The NCD may be recorded when a system is not powered or is off-line. Therefore, care needs to be taken when analysing “toggling” data as the characteristic may not indicate an unserviceable system or corrupted parameter.

3.15.7 Correlation with other parameters

3.15.7.1 The reasonableness check should include a check of the correlation between parameters that depend upon each other. For example, if roll increases, a turn is indicated and heading should begin to change soon after the increase is detected. Also, aileron position and control wheel position should have changed immediately before the roll is initiated. There may even be a variation in lateral acceleration. Again, it is important that the analyst confirms movement is indicated in the proper direction according to the aircraft sign convention.

3.15.7.2 Table 3-3 is provided as an aid to prepare a reasonableness checklist. It summarizes parameters in a 34-parameter FDRS that may be expected to interact. A check mark (✓) in a block indicates the parameter identified in the row and the parameter identified in the column are interdependent at some point during take-off and climb or approach and landing. Therefore, the movement of one parameter should cause or be caused by movement in the other. The following examples show how to use Table 3-3 in developing a reasonableness checklist for each parameter.

Example 1

Thrust reverser position reasonableness and quality check. In Table 3-3, the column labelled “thrust reverser positions” (number 22) contains check marks in the rows labelled “airspeed”, “engine thrust”, “longitudinal acceleration”, “automatic flight control system (AFCS) mode”, and “air/ground sensing”. The normal expectation is for the thrust reverser to deploy during rollout after landing. Thus, the following checklist may be developed using the parameters identified by a check mark:

a) examine the thrust reverser in-transit data and the thrust reverser-deployed data to determine that they indicate in-transit only for a short period during the landing roll and deployed at the end of the in-transit period. The data should indicate in-transit and the deployed discrete should indicate stowed near the end of the landing roll;

b) examine the engine thrust data during the in-transit period and immediately after the deployed indication. During the in-transit period, engine thrust should have decreased to near zero. Immediately after the thrust reverser-deployed indication, the engine thrust should have increased to near the maximum indication;

c) examine the airspeed and longitudinal thrust data. These two parameters should be decreasing during the in-transit period and should dramatically decrease immediately after the deployed indication;

d) examine the autopilot mode discrete and the air/ground sensing discrete. The autopilot mode discrete should indicate the autopilot has disengaged and the air/ground sensing switch discrete should indicate that the aircraft is on the ground; and

e) examine the remaining data for the thrust reverser discretes to ascertain that no in-transit or deployed indications appear. If intermittent indications appear, determine if they are within the allowable values and do not have sufficient duration to be interpreted as an actual deployment.

Example 2

Lateral control surface position reasonableness and quality check. The column labelled “lateral control surface positions” (number 16) contains check marks in the rows labelled “heading”, “roll attitude”, “lateral control positions” and “localizer deviation”. The lateral control surfaces are typically ailerons used in establishing the aircraft in a turn and returning the aircraft to straight flight from a turn. The lateral control surface position data may be checked along with the lateral control position data. These checks may be accomplished during the approach and landing segment:

a) examine the lateral control surface position trace for deviations during the initial approach segment. A large deviation would normally indicate the aircraft turning onto final approach heading. Check that the lateral control position and roll attitude make a large change at the same time;

b) check to determine that the heading begins to change immediately after the lateral control surface position begins to change. The heading should continue to change after the lateral control surface position returns to the zero or null value. The heading data should begin to change at a lower rate when the lateral control surface position data moves in the opposite direction. When the lateral control position is returned to zero or null, the heading data should again be constant;

c) check the localizer deviation for changes. Small lateral control surface position and lateral control position data changes should accompany deviations from the localizer and returns to the localizer course null; and

d) check the lateral control surface position data to determine there are no data dropouts and there is no noise in the data. If dropouts or noise are detected, determine they are within allowable values and they would not be interpreted as an actual control surface position movement.

Table 3-3. Parameter correlation

	1. Time	2. Altitude	3. Airspeed	4. Heading	5. Vertical acceleration	6. Pitch attitude	7. Roll attitude	8. Manual microphone keying	9. Engine thrust	10. Autopilot engagement	11. Longitudinal acceleration	12. Pitch control positions	13. Lateral control positions	14. Yaw control surface position	15. Pitch control surface positions	16. Lateral control surface positions	17. Yaw control surface positions	18 Lateral acceleration	19 Pitch trim surface positions	20. Trailing edge flaps	21. Leading edge flaps/slats	22. Thrust reverser positions	23. Ground spoiler position	24. OAT/TAT	25. Autopilot, AFCS modes	26. Radio altimeter	27. Localizer deviation	28. Glide slope deviation	29. Marker beacon	30. Master warning	31. Air/ground sensing	32. Angle of attack	33. Hydraulic pressure low	34. Ground speed
1. Time	■																																	
2. Altitude		■	✓	✓	✓			✓	✓	✓				✓			✓			✓	✓			✓		✓	✓		✓		✓			
3. Airspeed		✓	■																✓	✓	✓	✓	✓			✓					✓			✓
4. Heading		✓		■			✓						✓			✓																		
5. Vertical acceleration		✓			■	✓					✓	✓			✓			✓								✓					✓			
6. Pitch attitude					✓	■						✓			✓				✓									✓				✓		
7. Roll attitude				✓			■						✓			✓		✓									✓							
8. Manual microphone keying		✓						■																		✓								
9. Engine thrust		✓							■													✓				✓					✓			✓
10. Autopilot engagement		✓								■															✓						✓			
11. Longitudinal acceleration					✓						■							✓	✓	✓	✓	✓	✓								✓			
12. Pitch control positions					✓	✓						■			✓				✓									✓				✓		
13. Lateral control positions				✓			✓						■			✓											✓							
14. Yaw control positions		✓												■			✓									✓								
15. Pitch control surface positions					✓	✓						✓			■				✓									✓				✓		
16. Lateral control surface positions				✓			✓						✓			■											✓							
17. Yaw control surface positions		✓												✓			■									✓								
18. Lateral acceleration					✓		✓				✓							■																
19. Pitch trim surface positions			✓			✓					✓	✓			✓				■									✓						
20. Trailing edge flaps		✓	✓								✓									■	✓													✓
21. Leading edge flaps/slats		✓	✓								✓									✓	■													✓
22. Thrust reverser positions			✓						✓		✓											■			✓						✓			
23. Ground spoiler position			✓								✓												■											✓
24. OAT/TAT		✓																						■										
25. Autopilot, AFCS modes										✓												✓			■									✓
26. Radio altimeter		✓	✓		✓			✓	✓					✓			✓									■	✓	✓	✓		✓			
27. Localizer deviation		✓					✓						✓			✓										✓	■	✓						
28. Glide slope deviation						✓						✓			✓				✓							✓	✓	■						

	1. Time	2. Altitude	3. Airspeed	4. Heading	5. Vertical acceleration	6. Pitch attitude	7. Roll attitude	8. Manual microphone keying	9. Engine thrust	10. Autopilot engagement	11. Longitudinal acceleration	12. Pitch control positions	13. Lateral control positions	14. Yaw control surface position	15. Pitch control surface positions	16. Lateral control surface positions	17. Yaw control surface positions	18 Lateral acceleration	19 Pitch trim surface positions	20. Trailing edge flaps	21. Leading edge flaps/slats	22. Thrust reverser positions	23. Ground spoiler position	24. OAT/TAT	25. Autopilot, AFCS modes	26. Radio altimeter	27. Localizer deviation	28. Glide slope deviation	29. Marker beacon	30. Master warning	31. Air/ground sensing	32. Angle of attack	33. Hydraulic pressure low	34. Ground speed
29. Marker beacon		✓																								✓								
30. Master warning																																		
31. Air/ground sensing		✓	✓		✓				✓		✓											✓				✓								
32. Angle of attack						✓						✓			✓																			
33. Hydraulic pressure low																																		
34. Ground speed			✓						✓											✓	✓		✓		✓									

3.16 FLIGHT DATA RECORDER SYSTEM CALIBRATION

3.16.1 Functional check

3.16.1.1 A functional check is a quantitative check to determine if one or more functions of an item perform within specified limits. When applied to an FDR parameter, the functional check would determine if the recorded parameter is within the limits (range, accuracy, sampling rate and resolution) specified in the operating rule. The maintenance functional check should exercise the recording system from the sensor or transducer to check the range, accuracy, resolution and sampling rate of the recorded data.

3.16.1.2 The functional check procedures described in the following paragraphs are required for the commissioning of an FDR system after installation or modification. These procedures may be appropriate in providing some guidance in relation to the calibration of an FDR system and in developing a suitable schedule of maintenance that provides for the continuing airworthiness of the FDR system.

3.16.1.3 A functional check should comprise ground and/or flight tests and will vary in extent dependent upon whether the installation is classed as initial or follow-on. Generally, each parameter should be tested over its entire range of operation, the number of test points being dependent on the data source and how the source (data) is processed. The minimum number of test points is defined below. Required test points for a given parameter may be obtained by simulation, ground test, flight test or a combination of these methods.

3.16.2 Ground test

3.16.2.1 The following tests should be performed for a functional check of an FDR system when a ground test is needed:

a) insert definitive documentary data through the flight data entry panel, if installed (or equivalent device, e.g. flight deck clock suitably configured and wired or an event marker switch), to identify commencement of tests;

b) with the FDR system operating, perform a calibration check of all parameters and discretes. All sensors should be exercised over their effective range and all discretes exercised through their "off/on" states. Specific test points should be recorded to enable replay to confirm values;

c) sensors which may not be practical to exercise or stimulate for the purpose of calibration tests (e.g. fuel flow, torque, engine pressure ratio (EPR) may be simulated by appropriate test equipment;

d) the discrete calibration points should be predetermined and tabulated on a calibration record sheet. The calculated value in bits for each calibration point should be shown on the record sheet and the test operator should enter the value indicated on the test set. A typical example of an entry on the calibration record is shown in Table 3-4;

Table 3-4. Example of parameter calibration record

Pitch attitude: Number 013: Rate 16					
Selected calibration point	-10° DN	-5° DN	0°	+5° UP	+10° UP
Required value	655-665	673-683	689-699	703-713	716-726
Test set reading					

e) where the output of a sensor is indicated on flight-deck instruments and/or displays, the correlation between the indicated value and the predetermined calibration point should be established;

f) where a sensor output does not provide a flight-deck indication or where it results in an indication with resolution too low for correlation (e.g. position of flight control surfaces, spoilers, airbrakes) angle-measuring devices such as clinometers should be used to set predetermined test points required for calibration;

g) a minimum of five test points should be verified for each non-linear parameter and three test points should be verified for each linear parameter. Test points should include upper, transition and lower values (e.g. left, zero and right lateral deviation) and should confirm test points denoting to, from, north, south, east, west, plus, minus, etc. For parameters derived from flight deck controls having discrete detent positions (e.g. throttles, flaps), each detented position should be tested;

h) upon completion of ground test calibration and correlation testing, the FDR should be removed from the aircraft for data analysis. Alternatively, a suitable copy tape or download of the recording(s) should be obtained from the FDR *in situ* for subsequent playback assessment; and

i) to facilitate the assessment of all recorded data, the block of time allocated to ground testing may be suitably time-marked on the FDR such that the identification and assessment of the ground test data may be made later during the flight test data playback assessment.

3.16.3 Flight test

3.16.3.1 The flight test should be performed as the last test when it is deemed necessary after modifications are completed, but typically not during corrective maintenance. A flight test should be recommended when there is no other possible way to verify the calibration of the parameters and should be performed by a flight crew trained for the purpose. While it should be of minimal duration, it should nevertheless be of sufficient length to determine if there was any degradation of the recorded data when compared with the ground correlation and calibration data.

3.16.3.2 The flight test for an FDR system should include specific test points of all parameters and should cover a range of altitudes, including maximum certificated altitude of the aircraft. The test schedule should include the following, where practical, with all test points registered by means of a suitable event marker:

a) instrument and/or electronic display readings and recordings made at intervals during the flight for the purpose of determining data correlation of the required parameters;

b) unless conducted through the ground test segment, functioning of the equipment and systems in all modes and over their full ranges to generate the various discretes and variable parameters should be recorded;

c) unless conducted through ground testing, electrical power switching to demonstrate FDR system tolerance to transients and power interruptions;

d) operation of radio transmitters and electrical equipment (e.g. pumps, solenoids, motors, fans) to demonstrate FDR system immunity to electromagnetic interference (EMI);

e) for non-solid state recorders, implementation of a flight profile to demonstrate FDR system tolerance to vibration and acceleration; and

f) at completion of testing, the FDR should be removed from the aircraft for playback assessment. Alternatively, a suitable copy tape or download of the recording(s) should be obtained from the FDR *in situ* for subsequent playback assessment.

3.17 ADDITIONAL FDR PARAMETERS OR UPDATE OF SYSTEM

3.17.1 If new parameters or discrete signals are added to an existing FDR system, functional check testing is required. If the existing system can accommodate the change(s) without modification to FDR system components (e.g. if FDAU software changes are not required), confirmation of satisfactory performance should be established by means of a functional check of the additional FDR system inputs only. If the new parameters or discretes are derived from existing aircraft systems and require additional wiring or modifications to existing cable assemblies, an EMI programme should be conducted.

Note.— An assessment should be conducted to determine the need for re-testing of existing FDR parameters to confirm continued acceptability.

3.17.2 Where significant architectural and/or software changes result from the requirement to augment the list of parameters and/or discrete inputs to an FDR system, a functional check of the system would be necessary with ground-testing of all parameters and discretes required.

Note.— The need for a flight test should also be assessed.

3.17.3 Refer to Appendices A and B to Chapter 3 below for examples of FDR replay support documents.

3.18 ADRS MAINTENANCE

3.18.1 Lightweight flight recorder systems have been developed to promote the fitment of flight recorders to smaller aircraft. Rather than being a singularly dedicated accident investigation tool, operational use of data captured by lightweight flight recorder systems is encouraged.

3.18.2 Where the recorded information is being utilized as a debriefing tool, part of a safety management system (SMS) or other safety enhancement activity, the level of scrutiny should be assessed for equivalence to a reasonableness check. If the complete data set is being interrogated on a regular basis, then a credit should be considered to extend the time period between scheduled maintenance actions.

Appendix A to Chapter 3

Logo

[FLIGHT DATA RECORDER SYSTEM REPORT]

[… MAINTENANCE FACILITIES]

[Release Date]

[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.]

[Logo]	**Chapter 1** **[…] CIVIL AVIATION AUTHORITY** **Chapter 2** **[…] MAINTENANCE FACILITIES** FLIGHT DATA RECORDER SYSTEM REPORT		
Report Identifier	UK/AAIB-001	**Contract Number**	UK/AAIB-2016
Replay Date	12/4/2016	**Release Date**	14/4/2016
Aircraft Manufacturer/Model	Boeing/B757-200	**State of Registry**	United Kingdom
Aircraft Registration	G-ABCD	**Aircraft Serial Number**	012345
FDR Manufacturer/Model	L-3 Communication / FA2100 SSFDR		
FDR Part Number	2100-4043-02	**FDR Serial Number**	000123456
FAA TSO Number	TSO-C124a		
FAA TSO Requirement Authorized Deviation			
FDAU/DFDAU/DFDAC/DFDAF/ FDIMU Part Number	2233000-9X6	**FDAU/DFDAU/DFDAC/ DFDAF/FDIMU Serial Number**	0123456
Data Frame Layout Document Supplier	Boeing IC&RD	**Document Version**	D226A101-3
Sensor 1 Manufacturer/Model			
Sensor 1 Part Number		**Sensor 1 Serial Number**	
Sensor 2 Manufacturer/Model			
Sensor 2 Part Number		**Sensor 2 Serial Number**	
Sensor 3 Manufacturer/Model			
Sensor 3 Part Number		**Sensor 3 Serial Number**	
Sensor 4 Manufacturer/Model			
Sensor 4 Part Number		**Sensor 4 Serial Number**	
Sensor 5 Manufacturer/Model			
Sensor 5 Part Number		**Sensor 5 Serial Number**	
Sensor 6 Manufacturer/Model			
Sensor 6 Part Number		**Sensor 6 Serial Number**	

Sensor 7 Manufacturer/Model			
Sensor 7 Part Number		**Sensor 7 Serial Number**	
Sensor 8 Manufacturer/Model			
Sensor 8 Part Number		**Sensor 8 Serial Number**	
Sensor 9 Manufacturer/Model			
Sensor 9 Part Number		**Sensor 9 Serial Number**	
Sensor 10 Manufacturer/Model			
Sensor 10 Part Number		**Sensor 10 Serial Number**	
Sensor 11 Manufacturer/Model			
Sensor 11 Part Number		**Sensor 11 Serial Number**	
Sensor 12 Manufacturer/Model			
Sensor 12 Part Number		**Sensor 12 Serial Number**	
Sensor 13 Manufacturer/Model			
Sensor 13 Part Number		**Sensor 13 Serial Number**	
Sensor 14 Manufacturer/Model			
Sensor 14 Part Number		**Sensor 14 Serial Number**	
Sensor 15 Manufacturer/Model			
Sensor 15 Part Number		**Sensor 15 Serial Number**	
Sensor 16 Manufacturer/Model			
Sensor 16 Part Number		**Sensor 16 Serial Number**	
Sensor 17 Manufacturer/Model			
Sensor 17 Part Number		**Sensor 17 Serial Number**	
Sensor 18 Manufacturer/Model			
Sensor 18 Part Number		**Sensor 18 Serial Number**	
Sensor 19 Manufacturer/Model			
Sensor 19 Part Number		**Sensor 19 Serial Number**	

Sensor 20 Manufacturer/Model			
Sensor 20 Part Number		**Sensor 20 Serial Number**	
Sensor 21 Manufacturer/Model			
Sensor 21 Part Number		**Sensor 21 Serial Number**	
Sensor 22 Manufacturer/Model			
Sensor 22 Part Number		**Sensor 22 Serial Number**	
Sensor 23 Source		**Sensor 23 digital data bus source**	
Sensor 24 Source		**Sensor 24 digital data bus source**	
Sensor 25 Source		**Sensor 25 digital data bus source**	
Sensor 26 Source		**Sensor 26 digital data bus source**	
Sensor 27 Source		**Sensor 27 digital data bus source**	
Sensor 28 Source		**Sensor 28 digital data bus source**	
Sensor 29 Source		**Sensor 29 digital data bus source**	
Sensor 30 Source		**Sensor 30 digital data bus source**	
Sensor 31 Source		**Sensor 31 digital data bus source**	
Sensor 32 Source		**Sensor 32 digital data bus source**	
Sensor 33 Source		**Sensor 33 digital data bus source**	
Sensor 34 Source		**Sensor 34 digital data bus source**	
Sensor 35 Source		**Sensor 35 digital data bus source**	
Sensor 36 Source		**Sensor 36 digital data bus source**	
Pneumatic Input		**Pneumatic Input**	
Pneumatic Input		**Pneumatic Input**	
Pneumatic Input		**Pneumatic Input**	

Pneumatic Input		**Pneumatic Input**	
List of each parameter recorded (refer to Attachment 1)			
Wiring Diagram (refer to Attachment 2)			
System Schematic (refer to Attachment 3)			
Description of Parameters Recorded from Data Buses (refer to Attachment 4)			
Description of Structural Alterations			
Report Interpretation			
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.			
Action Officer		**Date**	

Table 3-A-1. List of each parameter recorded

Note.— Refer to Annex 6, Part I, Appendix 8 for original parameter list included for illustration purposes.

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
1	Time (UTC when available, otherwise relative time count or -GNSS time sync)	24 hours	4	±0.125%/h	1 s		
2	Pressure-altitude	–300 m (–1 000 ft) to maximum certificated altitude of aircraft +1 500 m (+5 000 ft)	1	±30 m to ±200 m (±100 ft to ±700 ft)	1.5 m (5 ft)		
3	Indicated airspeed or calibrated airspeed	95 km/h (50 kt) to maxV_{So} V_{So} to 1.2 V_D	1	±5% ±3%	1 kt (0.5 kt recommended)		
4	Heading (primary flight crew reference)	360°	1	±2°	0.5°		
5	Normal acceleration	–3 g to +6 g	0.125 (TC before 1 January 2016) 0.0625 (TC after 1 January 2016)	±1% of maximum range excluding datum error of ±5%	0.004 g		
6	Pitch attitude	±75° or usable range whichever is greater	0.25	±2°	0.5°		
7	Roll attitude	±180°	0.25	±2°	0.5°		
8	Radio transmission keying	On-off (one discrete)	1				
9	Power on each engine	Full range	1 (per engine)	±2%	0.2% of full range or the resolution required to operate the aircraft		

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
10	Trailing edge flap and cockpit control selection	Full range or each discrete position	2	±5% or as pilot's indicator	0.5% of full range or the resolution required to operate the aircraft		
11	Leading edge flap and cockpit control selection	Full range or each discrete position	2	±5% or as pilot's indicator	0.5% of full range or the resolution required to operate the aircraft		
12	Thrust reverser position	Stowed, in transit, and reverse	1 (per engine)				
13	Ground spoiler/speed brake selection (selection and position)	Full range or each discrete position	1	±2% unless higher accuracy uniquely required	0.2% of full range		
14	Outside air temperature	Sensor range	2	±2°C	0.3°C		
15	Autopilot/auto throttle/AFCS mode and engagement status	A suitable combination of discretes	1				
16	Longitudinal acceleration	±1 g	0.25 (TC before 1 January 2016) 0.0625 (TC after 1 January 2016)	±0.015 g excluding a datum error of ±0.05 g	0.004 g		
17	Lateral acceleration	±1 g	0.25 (TC before 1 January 2016) 0.0625 (TC after 1 January 2016)	±0.015 g excluding a datum error of ±0.05 g	0.004 g		

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
18	Pilot input and/or control surface position-primary controls (pitch, roll, yaw)	Full range	0.25 (TC before 1 January 2016) 0.125 (TC after 1 January 2016)	±2° unless higher accuracy uniquely required	0.2% of full range or as installed		
19	Pitch trim position	Full range	1	±3% unless higher accuracy uniquely required	0.3% of full range or as installed		
20	Radio altitude	–6 m to 750 m (–20 ft to 2 500 ft)	1	±0.6 m (±2 ft) or ±3% whichever is greater below 150 m (500 ft) and ±5% above 150 m (500 ft)	0.3 m (1 ft) below 150 m (500 ft) 0.3 m (1 ft) + 0.5% of full range above 150 m (500 ft)		
21	Vertical beam deviation (ILS/GNSS/GLS glide path, MLS elevation, IRNAV/IAN vertical deviation)	Signal range	1	±3%	0.3% of full range		
22	Horizontal beam deviation (ILS/GNSS/GLS localizer, MLS azimuth, IRNAV/IAN lateral deviation)	Signal range	1	±3%	0.3% of full range		
23	Marker beacon passage	Discrete	1				
24	Master warning	Discrete	1				

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
25	Each NAV receiver frequency selection	Full range	4	As installed			
26	DME 1 and 2 distance (includes Distance to runway threshold (GLS) and Distance to missed approach point (IRNAV/IAN)	0–370 km (0–200 NM)	4	As installed	1 852 m (1 NM)		
27	Air/ground status	Discrete	1				
28	GPWS/TAWS/GCAS status (selection of terrain display mode including pop-up display status) and (terrain alerts, both cautions and warnings, and advisories) and (on/off switch position)	Discrete	1				
29	Angle of attack	Full range	0.5	As installed	0.3% of full range		
30	Hydraulics, each system (low pressure)	Discrete	2		0.5% of full range		
31	Navigation data (latitude/longitude, ground speed and drift angle)	As installed	1	As installed			
32	Landing gear and gear selector position	Discrete	4	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
33	Groundspeed	As installed	1	Data should be obtained from the most accurate system	1 kt		
34	Brakes (left and right brake pressure, left and right brake pedal position)	(Maximum metered brake range, discretes or full range)	1	±5%	2% of full range		
35	Additional engine parameters (EPR, N_1, indicated vibration level, N_2, EGT, fuel flow, fuel cut-off lever position, N_3, engine fuel metering valve position) (engine fuel metering valve position TC after 1 January 2023)	As installed		As installed	2% of full range		
36	TCAS/ACAS (traffic alert and collision avoidance system)	Discrete	1	As installed			
37	Wind shear warning	Discrete	1	As installed			
38	Selected barometric setting (pilot, co-pilot)	As installed	64	As installed	0.1 mb (0.01 in-Hg)		
39	Selected altitude (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
40	Selected speed (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
41	Selected Mach (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
42	Selected vertical speed (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
43	Selected heading (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
44	Selected flight path (all pilot selectable modes of operation) (course/DSTRK, path angle, final approach path (IRNAV/IAN))		1	As installed			
45	Selected decision height	As installed	64	As installed	Sufficient to determine crew selection		
46	EFIS display format (pilot, co-pilot)	Discrete(s)	4	As installed			
47	Multi-function/engine/alerts display format	Discrete(s)	4	As installed			
48	AC electrical bus status	Discrete(s)	4	As installed			
49	DC electrical bus status	Discrete(s)	4	As installed			
50	Engine bleed valve position	Discrete(s)	4	As installed			
51	APU bleed valve position	Discrete(s)	4	As installed			
52	Computer failure	Discrete(s)	4	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
53	Engine thrust command	As installed	2	As installed			
54	Engine thrust target	As installed	4	As installed	2% of full range		
55	Computed centre of gravity	As installed	64	As installed	1% of full range		
56	Fuel quantity in CG trim tank	As installed	64	As installed	1% of full range		
57	Head up display in use	As installed	4	As installed			
58	Para visual display on/off	As installed	1	As installed			
59	Operational stall protection, stick shaker and pusher activation	As installed	1	As installed			
60	Primary navigation system reference (GNSS, INS, VOR/DME, MLS, Loran C, localizer glideslope)	As installed	4	As installed			
61	Ice detection	As installed	4	As installed			
62	Engine warning each engine vibration	As installed	1	As installed			
63	Engine warning each engine over temperature	As installed	1	As installed			
64	Engine warning each engine oil pressure low	As installed	1	As installed			
65	Engine warning each engine over speed	As installed	1	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
66	Yaw trim surface position	Full range	2	±3% unless higher accuracy uniquely required	0.3% of full range		
67	Roll trim surface position	Full range	2	±3% unless higher accuracy uniquely required	0.3% of full range		
68	Yaw or sideslip angle	Full range	1	±5%	0.5°		
69	De-icing and/or anti-icing systems selection	Discrete(s)	4				
70	Hydraulic pressure (each system)	Full range	2	±5%	100 psi		
71	Loss of cabin pressure	Discrete	1				
72	Cockpit trim control input position, Pitch	Full range	1	±5%	0.2% of full range or as installed		
73	Cockpit trim control input position, Roll	Full range	1	±5%	0.2% of full range or as installed		
74	Cockpit trim control input position, Yaw	Full range	1	±5%	0.2% of full range or as installed		
75	All cockpit flight control input forces (control wheel, control column, rudder pedal)	Full range (±311 N (±70 lbf), ± 378 N (±85 lbf), ± 734 N (±165 lbf))	1	±5%	0.2% of full range or as installed		
76	Event marker	Discrete	1				
77	Date	365 days	64				
78	ANP or EPE or EPU	As installed	4	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR readout)*	*Recording resolution*	*No shows*	*Anomalies noted*
79	Cabin pressure altitude (TC after 1 January 2023)	As installed (0 ft to 40 000 ft recommended)	1	As installed	100 ft		
80	Aeroplane computed weight (TC after 1 January 2023)	As installed	64	As installed	1% of full range		
81	Flight director command (TC after 1 January 2023)	Full range	1	± 2º	0.5°		
82	Vertical speed (TC after 1 January 2023)	As installed	0.25	As installed (32 ft/min recommended)	16 ft/min		

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Appendix B to Chapter 3

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[FLIGHT DATA RECORDER READOUT REPORT]

[… MAINTENANCE FACILITIES]

[Release Date]

[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.]

[Logo]	**Chapter 3** **[…] CIVIL AVIATION AUTHORITY** **Chapter 4** **[…] MAINTENANCE FACILITIES** FLIGHT DATA RECORDER READOUT REPORT		
Report Identifier	UK/AAIB-001	**Contract Number**	UK/AAIB-2016
Replay Date	12/4/2016	**Release Date**	14/4/2016
Aircraft Manufacturer/Model	Airbus/A320-200	**State of Registry**	United Kingdom
Aircraft Registration	G-ABCD	**Aircraft Serial Number**	012345
FDR Manufacturer/Model	L-3 Communication/FA2100 SSFDR		
FDR Part Number	2100-4043-02	**FDR Serial Number**	000123456
Data Duration 170 hours	**Parameters Replayed**	1200	
Audio Duration 120 minutes	**Recording Quality**	Good	
Data Link Duration N/A	**Recording Content**	N/A	
Data Acquisition Unit			
Data Frame Layout Document Supplier	Airbus FDRPL SA	**Document Version**	9.0.0.383
Download Validation Equipment	ROSE (Read-Out Support Equipment) Analysis Unit		
Part Number	17TES0070	**Serial Number**	0123456
Compliance with ICAO Annex 6 General FDR Parameter Requirement (refer to Table 3-B-1 below)			
Reason for Data Loss			
FDR Failure ☐	*Desynchronizations* ☐	*Other* ☐	
Report Interpretation			
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.			
Action Officer		**Date**	

Table 3-B-1. Compliance with Annex 6, Part I, Appendix 8, for flight data recorders requirement

Note.— Refer to Annex 6, Part I, Appendix 8 for original parameter list included for illustration purposes.

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
1	Time (UTC when available, otherwise relative time count or GNSS time sync)	24 hours	4	±0.125%/h	1 s		
2	Pressure-altitude	–300 m (–1 000 ft) to maximum certificated altitude of aircraft +1 500 m (+5 000 ft)	1	±30 m to ±200 m (±100 ft to ±700 ft)	1.5 m (5 ft)		
3	Indicated airspeed or calibrated airspeed	95 km/h (50 kt) to maxV_{So} V_{So} to 1.2 V_D	1	±5% ±3%	1 kt (0.5 kt recommended)		
4	Heading (primary flight crew reference)	360°	1	±2°	0.5°		
5	Normal acceleration	–3 g to +6 g	0.125 (TC before 1 January 2016) 0.0625 (TC after 1 January 2016)	±1% of maximum range excluding datum error of ±5%	0.004 g		
6	Pitch attitude	±75° or usable range whichever is greater	0.25	±2°	0.5°		
7	Roll attitude	±180°	0.25	±2°	0.5°		
8	Radio transmission keying	On-off (one discrete)	1				
9	Power on each engine	Full range	1 (per engine)	±2%	0.2% of full range or the resolution required to operate the aircraft		

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
10	Trailing edge flap and cockpit control selection	Full range or each discrete position	2	±5% or as pilot's indicator	0.5% of full range or the resolution required to operate the aircraft		
11	Leading edge flap and cockpit control selection	Full range or each discrete position	2	±5% or as pilot's indicator	0.5% of full range or the resolution required to operate the aircraft		
12	Thrust reverser position	Stowed, in transit, and reverse	1 (per engine)				
13	Ground spoiler/speed brake selection (selection and position)	Full range or each discrete position	1	±2% unless higher accuracy uniquely required	0.2% of full range		
14	Outside air temperature	Sensor range	2	±2°C	0.3°C		
15	Autopilot/auto throttle/AFCS mode and engagement status	A suitable combination of discretes	1				
16	Longitudinal acceleration	±1 g	0.25 (TC before 1 January 2016) 0.0625 (TC after 1 January 2016)	±0.015 g excluding a datum error of ±0.05 g	0.004 g		
17	Lateral acceleration	±1 g	0.25 (TC before 1 January 2016) 0.0625 (TC after 1 January 2016)	±0.015 g excluding a datum error of ±0.05 g	0.004 g		

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
18	Pilot input and/or control surface position-primary controls (pitch, roll, yaw)	Full range	0.25 (TC before 1 January 2016) 0.125 (TC after 1 January 2016)	±2° unless higher accuracy uniquely required	0.2% of full range or as installed		
19	Pitch trim position	Full range	1	±3% unless higher accuracy uniquely required	0.3% of full range or as installed		
20	Radio altitude	–6 m to 750 m (–20 ft to 2 500 ft)	1	±0.6 m (±2 ft) or ±3% whichever is greater below 150 m (500 ft) and ±5% above 150 m (500 ft)	0.3 m (1 ft) below 150 m (500 ft) 0.3 m (1 ft) + 0.5% of full range above 150 m (500 ft)		
21	Vertical beam deviation (ILS/GNSS/GLS glide path, MLS elevation, IRNAV/IAN vertical deviation)	Signal range	1	±3%	0.3% of full range		
22	Horizontal beam deviation (ILS/GNSS/GLS localizer, MLS azimuth, IRNAV/IAN lateral deviation)	Signal range	1	±3%	0.3% of full range		
23	Marker beacon passage	Discrete	1				
24	Master warning	Discrete	1				

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
25	Each NAV receiver frequency selection	Full range	4	As installed			
26	DME 1 and 2 distance (includes Distance to runway threshold (GLS) and Distance to missed approach point (IRNAV/IAN)	0–370 km (0–200 NM)	4	As installed	1 852 m (1 NM)		
27	Air/ground status	Discrete	1				
28	GPWS/TAWS/GCAS status (selection of terrain display mode including pop-up display status) and (terrain alerts, both cautions and warnings, and advisories) and (on/off switch position)	Discrete	1				
29	Angle of attack	Full range	0.5	As installed	0.3% of full range		
30	Hydraulics, each system (low pressure)	Discrete	2		0.5% of full range		
31	Navigation data (latitude/longitude, ground speed and drift angle)	As installed	1	As installed			
32	Landing gear and gear selector position	Discrete	4	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
33	Groundspeed	As installed	1	Data should be obtained from the most accurate system	1 kt		
34	Brakes (left and right brake pressure, left and right brake pedal position)	(Maximum metered brake range, discretes or full range)	1	±5%	2% of full range		
35	Additional engine parameters (EPR, N_1, indicated vibration level, N_2, EGT, fuel flow, fuel cut-off lever position, N_3, engine fuel metering valve position) (engine fuel metering valve position TC after 1 January 2023)	As installed		As installed	2% of full range		
36	TCAS/ACAS (traffic alert and collision avoidance system)	Discrete	1	As installed			
37	Wind shear warning	Discrete	1	As installed			
38	Selected barometric setting (pilot, co-pilot)	As installed	64	As installed	0.1 mb (0.01 in-Hg)		
39	Selected altitude (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
40	Selected speed (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
41	Selected Mach (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
42	Selected vertical speed (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
43	Selected heading (all pilot selectable modes of operation)	As installed	1	As installed	Sufficient to determine crew selection		
44	Selected flight path (all pilot selectable modes of operation) (course/DSTRK, path angle, final approach path (IRNAV/IAN))		1	As installed			
45	Selected decision height	As installed	64	As installed	Sufficient to determine crew selection		
46	EFIS display format (pilot, co-pilot)	Discrete(s)	4	As installed			
47	Multi-function/engine/alerts display format	Discrete(s)	4	As installed			
48	AC electrical bus status	Discrete(s)	4	As installed			
49	DC electrical bus status	Discrete(s)	4	As installed			
50	Engine bleed valve position	Discrete(s)	4	As installed			
51	APU bleed valve position	Discrete(s)	4	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
52	Computer failure	Discrete(s)	4	As installed			
53	Engine thrust command	As installed	2	As installed			
54	Engine thrust target	As installed	4	As installed	2% of full range		
55	Computed centre of gravity	As installed	64	As installed	1% of full range		
56	Fuel quantity in CG trim tank	As installed	64	As installed	1% of full range		
57	Head up display in use	As installed	4	As installed			
58	Para visual display on/off	As installed	1	As installed			
59	Operational stall protection, stick shaker and pusher activation	As installed	1	As installed			
60	Primary navigation system reference (GNSS, INS, VOR/DME, MLS, Loran C, localizer glideslope)	As installed	4	As installed			
61	Ice detection	As installed	4	As installed			
62	Engine warning each engine vibration	As installed	1	As installed			
63	Engine warning each engine over temperature	As installed	1	As installed			
64	Engine warning each engine oil pressure low	As installed	1	As installed			
65	Engine warning each engine over speed	As installed	1	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
66	Yaw trim surface position	Full range	2	±3% unless higher accuracy uniquely required	0.3% of full range		
67	Roll trim surface position	Full range	2	±3% unless higher accuracy uniquely required	0.3% of full range		
68	Yaw or sideslip angle	Full range	1	±5%	0.5°		
69	De-icing and/or anti-icing systems selection	Discrete(s)	4				
70	Hydraulic pressure (each system)	Full range	2	±5%	100 psi		
71	Loss of cabin pressure	Discrete	1				
72	Cockpit trim control input position, Pitch	Full range	1	±5%	0.2% of full range or as installed		
73	Cockpit trim control input position, Roll	Full range	1	±5%	0.2% of full range or as installed		
74	Cockpit trim control input position, Yaw	Full range	1	±5%	0.2% of full range or as installed		
75	All cockpit flight control input forces (control wheel, control column, rudder pedal)	Full range (±311 N (±70 lbf), ± 378 N (±85 lbf), ± 734 N (±165 lbf))	1	±5%	0.2% of full range or as installed		
76	Event marker	Discrete	1				
77	Date	365 days	64				
78	ANP or EPE or EPU	As installed	4	As installed			

Serial number	*Parameter*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*	*No shows*	*Anomalies noted*
79	Cabin pressure altitude (TC after 1 January 2023)	As installed (0 ft to 40 000 ft recommended)	1	As installed	100 ft		
80	Aeroplane computed weight (TC after 1 January 2023)	As installed	64	As installed	1% of full range		
81	Flight director command (TC after 1 January 2023)	Full range	1	± 2º	0.5°		
82	Vertical speed (TC after 1 January 2023)	As installed	0.25	As installed (32 ft/min recommended)	16 ft/min		

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Appendix C to Chapter 3

INTRODUCTION TO ARINC 717 DATA FRAMES

1. A flight data acquisition unit (FDAU) takes the aircraft analogue and ARINC 428 digital inputs and condenses the data into a multiplexed digital data stream per ARINC 717 for recording onto the flight data recorder. When the data is extracted, the process has to be reversed and the raw binary data has to be converted back into engineering units (EUs).

2. This decoding process has two phases. The first is to know which data bits correspond to which variable parameters as defined by the data frame 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 data frame definition defines the bit map and scaling laws that allow conversion between raw binary and EUs.

3. The number of bits that a parameter occupies determines the number of states contained in a given parameter. Thus, a parameter stored in 12 bits can have 4 096 possible states (range of 0 to 4 095 counts, see Table 3-C-1). 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.

Table 3-C-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 refers to most significant bit and LSB refers to least significant bit.

4. A parameter's sample rate is the number of recordings made by the FDR 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 FDR is determined by the regulations and should be distinguished from the rate at which the parameter is refreshed on the FDAU input bus. Thus, whilst the gross weight may be refreshed every 20 milliseconds at the FDAU 429 input port, it will only be recorded every 64 seconds on the FDR. It is important that the data bus refresh rate is consistent with (faster than) the required data capture rate to avoid stale data.

5. *What is an ARINC 717 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 be comprised of multiples of 64 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 640 being equivalent to the maximum available using the two least significant bits of this counter = 77 0. For the purposes of this section, a data rate of 1 024 words per second is used, and at 12 bits/word, this corresponds to a bit rate of 12 288 bits/s.

6. *ARINC 717 data frame structure*

6.1 An FDR frame occupies a four-second interval, within which are four one-second subframes, called subframes 1, 2, 3 and 4. These sub-frames appear in sequential order throughout the data as the sub-frame pattern repeats for each new frame.

6.2 The ARINC Characteristic 573 (Mark 2 aircraft integrated data system) data frame concept developed at the point when tape damaged due to crash loads was a concern. ARINC defined a set of synchronization 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.

6.3 In good flight data, once the sync word for subframe 1 has been found, moving 1 024 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 synchronized. Any unsynchronized 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.

6.4 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 4 095 counts), 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 FDAU. 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.

6.5 Each four-second 1 024 words per second frame can generate 4 092 12-bit words (64 096 available, minus the 4 sync words), or 49 104 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 FDR data frames, range, resolution and sample rates are set by the regulations for all mandatory parameters.

6.6 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 FDR 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°C 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

6.7 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.

6.8 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. The Nz requires eight words per data frame, and these must be spread evenly through the 1 024 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.

6.9 As data frames developed, designers found that they had more parameters to record than there were words to store. To increase the possibilities available, the superframe was defined. In this concept, a sixty-four second superframe consists of sixteen four-second frames. The superframe counter 1-16 (0 to 15 counts) determines the recording position within the 16-frame sequence (see Figure 3-C-1 below).

6.10 If a parameter is recorded in only one of the four subframes (e.g. subframe 1) and only one of the 16 frames (e.g. frame 5), the sample rate will be {subframe 1 every 4 seconds} x {16 frames per superframe cycle} = once every 64 seconds. If the parameter is placed in all four subframes, the sample rate becomes {each subframe every second} x {16 frames per superframe cycle} = once every 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.

6.11 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.

6.12 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 2n combinations. For example, four discretes could be combined to represent 16 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 (flight data acquisition unit) that purely samples and stores the input data within a serial data frame for recording on the FDR. However, this coding process must be determined to permit accurate re-conversion of the recorded data into engineering terms.

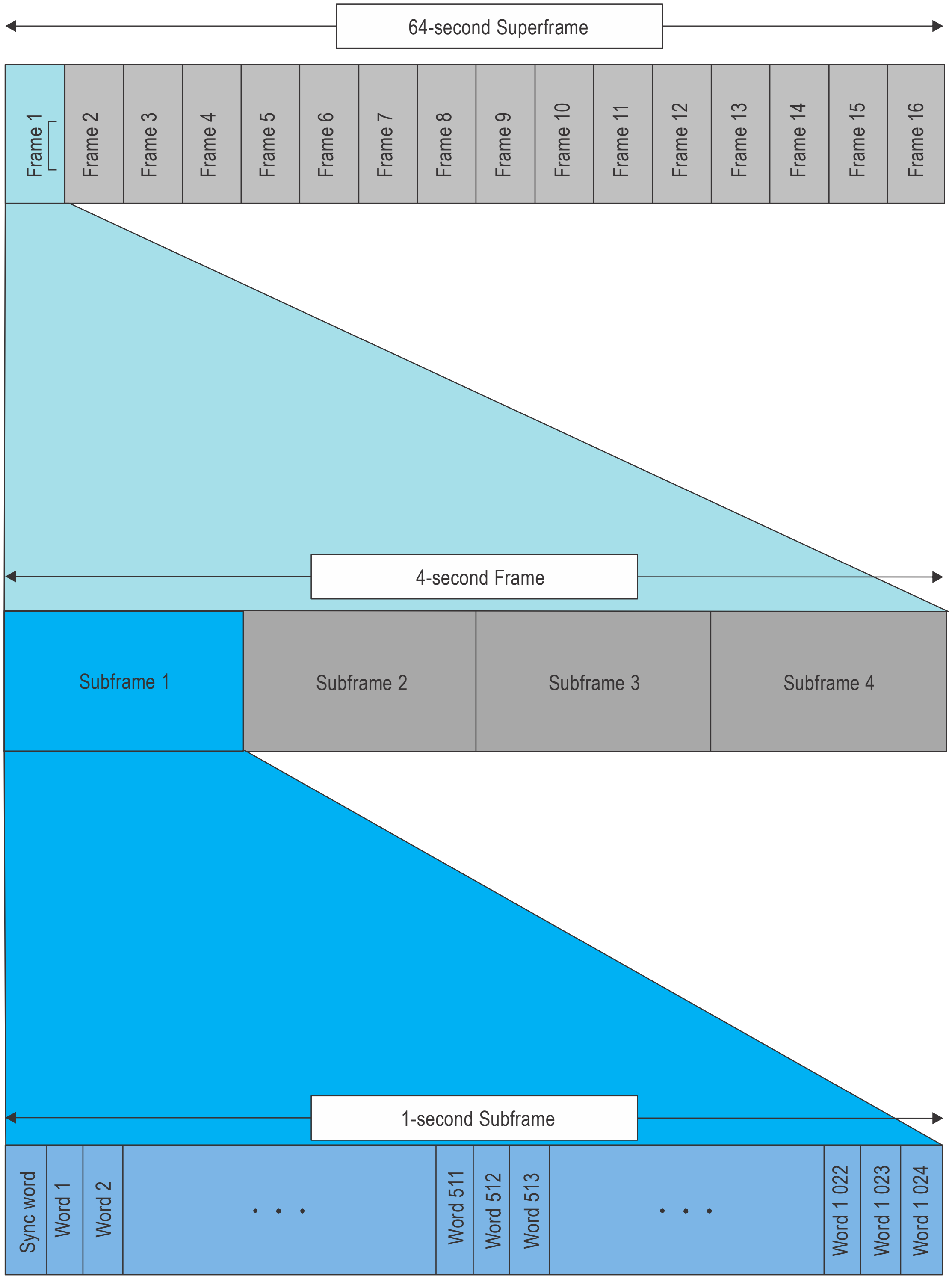


Figure 3-C-1. Superframe layout

7. *ARINC 717 data conversions*

7.1 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 3-C-1 above shows the number of states possible for different number 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 in Table 3-C-1, the data word has a maximum range of 8 190 with a resolution of 2.

7.2 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.

7.3 To describe the process of converting digital data into the FDR system data format, 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/4 095 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).

7.4 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).

7.5 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.

7.6 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.

7.7 In order to convert into EUs, it is then necessary to apply the signal source LRUs 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 direct current (LLDC) input will be accepted with an input range of 0 to 5 Vdc with 0 V being recorded as 0 counts and 5 V 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 (EU) 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 -3.375 g to +6.0 g, giving an input range of 9.375 g. As this is a bipolar input (+ and - ranges), the data is handled as an offset bipolar word with a -3.375 g offset.

Therefore, for a Nz of 2.0 g:

Digital counts, 12 bits = 4 095 x (2 g + 3.375 g)/9.375 g = 2 348 decimal or 4 454 octal counts.

Resolution, 12 bits = total input range (gravities)/total range (counts) = 9.375 g/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 +6.0 g and therefore 0 counts = -3.375 g, an actual value and is thus considered as an "inclusive" range.

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

7.8 A discrete parameter indicates a change of a single function. Table 3-C-2 illustrates how the recording of an aircraft transition from air to ground during landing can be represented by a single bit changing state.

Table 3-C-2. Single bit discrete representing air-to-ground transition

Discrete state	12	11	10	9	8	7	6	5	4	3	2	1
Air	x	x	x	x	x	x	x	x	x	x	x	0
Ground	x	x	x	x	x	x	x	x	x	x	x	1

Discrete parameters representing several individual functions in an associated aircraft system may be grouped together. Two bits can represent a change in four functions. Table 3-C-3 illustrates how the operation of an engine thrust reverser system may be represented by two bits changing state.

Table 3-C-3. Multiple bit discrete representing thrust reverser operation

Discrete state	12	11	10	9	8	7	6	5	4	3	2	1
Engine X thrust reverser invalid	x	x	x	x	x	x	x	x	x	x	0	0
Engine X thrust reverser stowed	x	x	x	x	x	x	x	x	x	x	0	1
Engine X thrust reverser in transit	x	x	x	x	x	x	x	x	x	x	1	0
Engine X thrust reverser deployed	x	x	x	x	x	x	x	x	x	x	1	1

Example of data frame layout

Tables 3-C-4 to 3-C-16 provide examples of a data frame layout and how some parameters are recorded.

Table 3-C-4. 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 3	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	LS 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	61 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	524 3	RH ROLL SPOILER	62 51	FRAME COUNT STAIR TEMP LATITUDE LSP STAIR 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	LK ELEVATOR POS'N	56 47	LH AILERON POS'N	66 55	RH ELEVATOR POS'N	76 63	LH 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 DISCRETE	77 64	N1 ENGINE #4

Table 3-C-5. Data frame format — discrete frame

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	2		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 SHAKER	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 58		N1 #3 VALID	67 56			77 64	RAD ALT NORMAL SOURCE	N1 #4 VALID

Table 3-C-6. 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 ACTVE	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	PYLO 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	LONGST 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

Frame	SUPERFRAME 1 Parameter	SUPERFRAME 2 Parameter	ILS 1 & 2 FREQUENCY 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 3-C-7. Source definition

Signal source/type	*Code representation*	*Bits (Bit 0 = LSB)*	*Min update rate (times/s)*	*SDI BITS 10*	*SDI BITS 9*
A.D.C. 1 ARINC 429 DATABUS LABEL 203	BNR	28 to 11	62.5 ms (16/s)	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 operations manual		

Table 3-C-8. Recording definition

FDR word No(s)	*Superframe No.*	*Bits (Bits 1 = LSB)*	*Sampling INT (s)*
Octal: 071 Decimal: 58 SF 1	N/A	12 to 2 (Bit 1 – Validity)	1
Resolution/LSB Value	*Range*	*Conversion accuracy*	*Overall RSS accuracy*
2 ft	-1.024 to 64 512 ft	–	Defined in operations manual

Figure 3-C-2 below indicates the related transport delays:

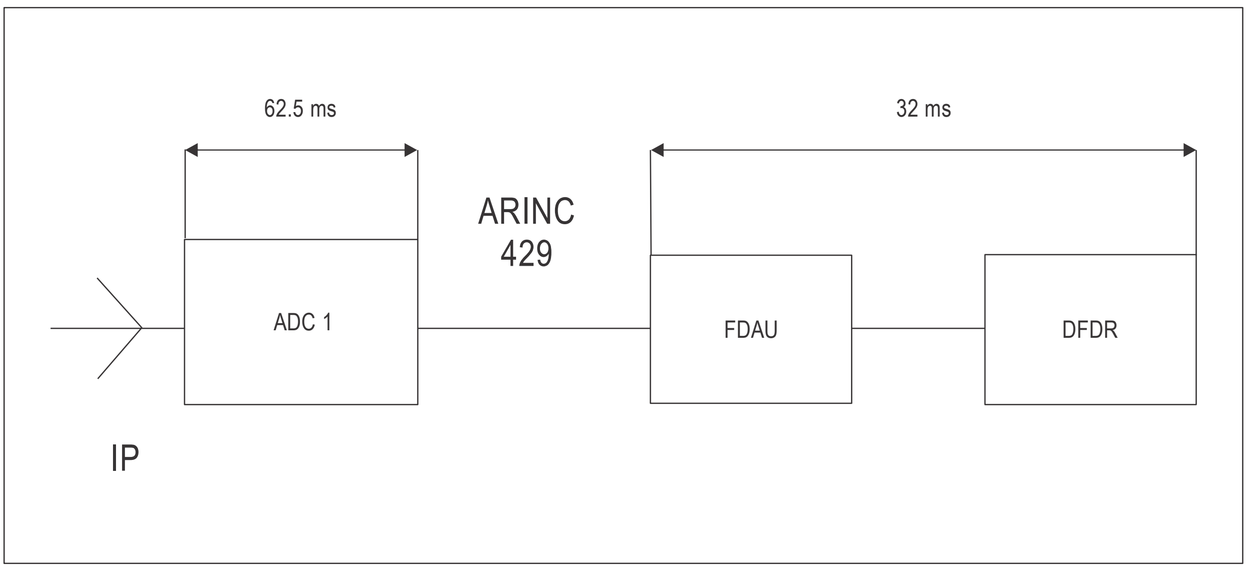


Figure 3-C-2. Transport delay(s)

Algorithm

Defined in operations manual

Sign convention (digital source)	sign bit 29	– 0 – positive – 1 – negative

Parameter: Pressure altitude (coarse)

Table 3-C-9. Source definition

Signal source/type	*Code representation*	*Bits (Bit 0 = LSB)*	*Min update rate (times/s)*	*SDI BITS*	
				10	*9*
A.D.C. 1 ARINC 429 DATABUS LABEL 203	BNR	28 to 11	62.5 ms (16/s)	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 operations manual		

Table 3-C-10. Recording definition

FDR word No(s)	*Superframe No.*	*Bits (Bits 1 = LSB)*	*Sampling INT (s)*
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 operations manual

Algorithm

Defined in operations manual

Sign convention (digital source)	sign bit 29	– 0 – positive – 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 (12bit)	=	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: Computed airspeed

Table 3-C-11. Source definition

Signal source/type	*Code representation*	*Bits (Bit 0 = LSB)*	*Min update rate (times/s)*	*SDI BITS 10*	*SDI BITS 9*
A.D.C. 1 ARINC 429 DATABUS LABEL 206	BNR	28 to 15	62.5 ms (16/s)	0	1
Resolution/LSB value	*Range*		*Accuracy*		
0.0625 kt	Operating: 30 to 450 kt Output: 0.0 to 500 kt		60 kt - +/- 4 kt 100 kt - +/- 2 kt 200 kt - +/- 1 kt 450 kt - +/- 1 kt		

Table 3-C-12. Recording definition

FDR Word No(s)	*Superframe No.*	*Bits (Bits 1 = LSB)*	*Sampling INT (s)*
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% at 60 kt ± 2% at 100 kt ± 0.5% at 200 kt ± 0.2% at 450 kt

Figure 3-C-3 below indicates the related transport delay:

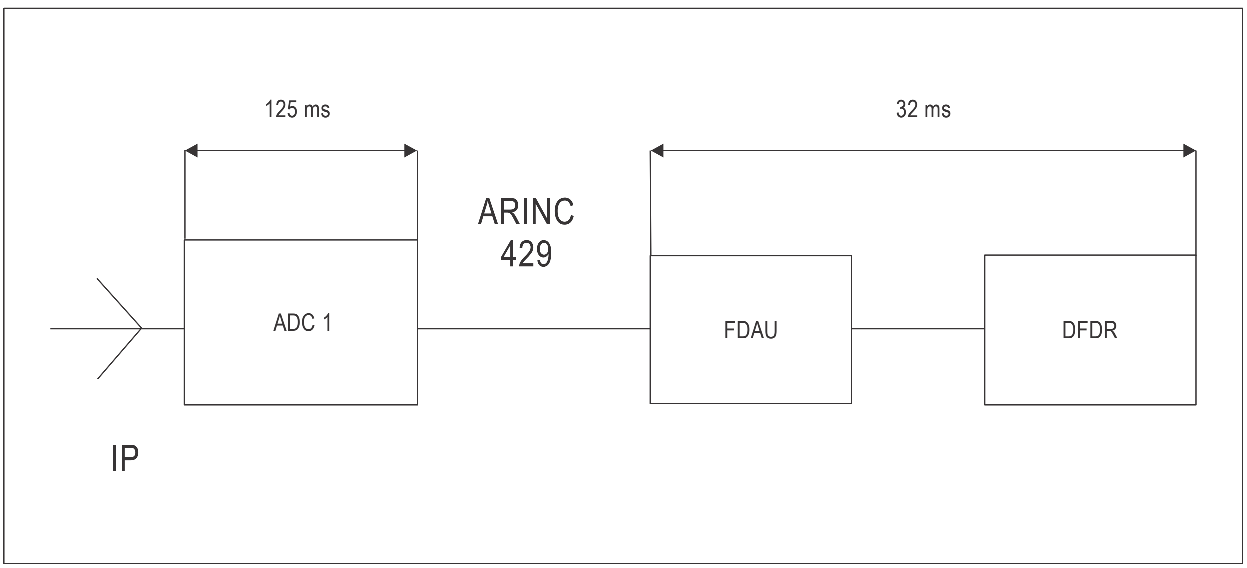


Figure 3-C-3. Transport delay(s)

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 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 (digital source)	sign bit 29	– 0 – positive – 1 – negative

Parameter: Magnetic heading

Table 3-C-13. Source definition

Signal source/type	*Code representation*	*Bits (Bit 0 = LSB)*	*Min update rate (times/s)*	*SDI BITS 10*	*SDI BITS 9*
I.R.U. 1 ARINC 429 DATABUS LABEL 320	BNR	28 to 13	400 ms 2.5/s	0	1
Resolution/LSB value	*Range*		*Accuracy*		
0.0055°	± 180°		AT +/- 50° Lat - 2° 50 to 79° N Lat - 3° 50 to 60° S Lat - 3° Above 79° N Lat - 8°		

Table 3-C-14. Recording definition

FDR word No(s)	*Superframe No.*	*Bits (Bits 1 = LSB)*	*Sampling INT (s)*
Octal: 010	N/A	12 to 2 (Bit 1 – Validity)	1
Decimal: 9 SF 1			
Resolution/LSB value	*Range*	*Conversion accuracy*	*Overall RSS accuracy*
0.18°	0° to 360° (±180°)	–	As above

Figure 3-C-4 below indicates the related transport delay:

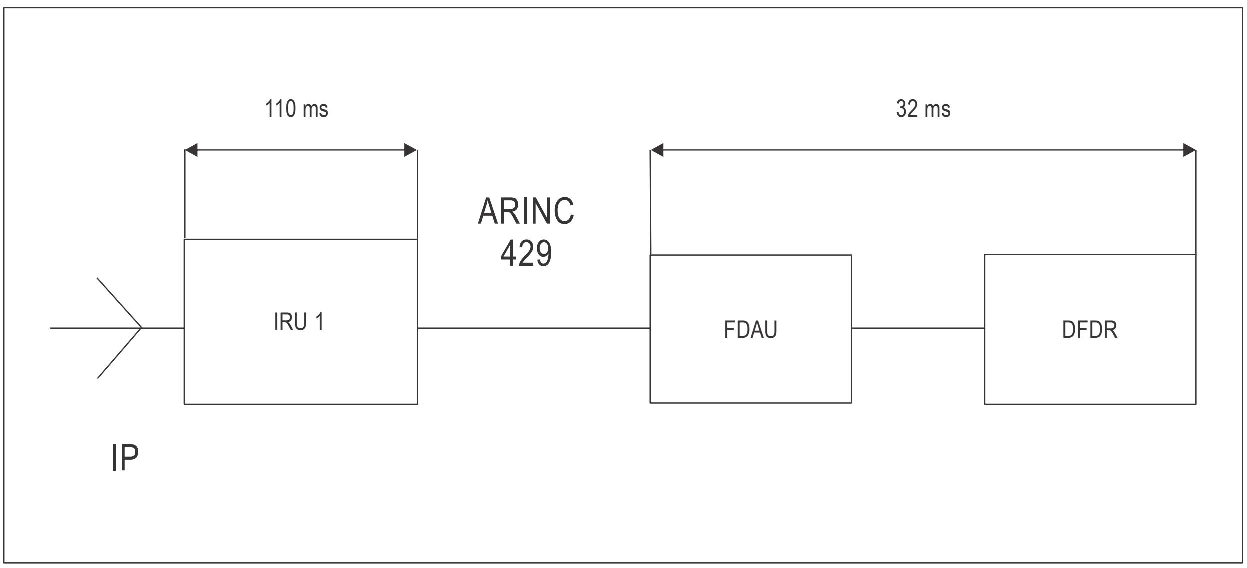


Figure 3-C-4. Transport delay(s)

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	19	V	– ARINC Data

Note.— The above bit patterns for recorded and ARINC Data are nominal only.

Sign convention (digital source)	sign bit 29	– 0 – positive (0° to 180°) – 1 – negative (180° to 360°)

Parameter: Normal Acceleration

Table 3-C-15. Source definition

Signal source/type	*Code representation*	*Bits (Bit 0 = LSB)*	*Min update rate (times/s)*	*SDI BITS 10*	*SDI BITS 9*
Tri-Axial Accelorometer Magnatek or Sunolstrand	N/A	N/A	N/A	N/A	
Resolution/LSB value	*Range*		*Accuracy*		
Infinite	-3.375 g to +6.0 g		± 0.75% FSO		

Table 3-C-16. Recording definition

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

Transport Delay(s)

FDAU/DFDR conversion delay only = 32 ms

Algorithm

FDR range 0 to 4 096 digital counts where:
Acceleration (g) = (2.289 x 10^{-3} x (FDR digital count (12 Bit))) – 3.375

Scale	**Range**	**Output**
Up	+6 g	5 000 mV
Down	-3 g	200 mV

Sign convention
(Digital source) N/A

Appendix D to Chapter 3

ARINC 767 EAFR REPLAY SUPPORT DOCUMENTS

1. **Introduction to ARINC 767 data frames**

The ARINC 717 data frame concepts in section 3.16.1 apply also to ARINC 767 data frames with the exception that an enhanced airborne flight recorder (EAFR) flight data acquisition function (FDAF) takes the aircraft digital inputs provided by ARINC 664 ethernet (rather than analogue and ARINC 429 digital inputs) and condenses the data for recording in crash-protected memory (a separate FDR is not used).

2. **What is an ARINC 767 data frame?**

2.1 The ARINC 767 data frame includes up to 255 frames with two reserved frames:

a) the documentary data frame identifies recorded flight data; and

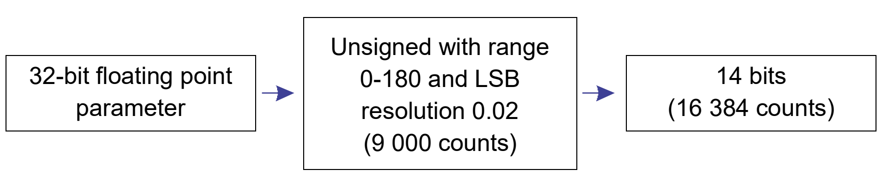
b) the mark-time frame provides an indication of how long aircraft systems are offline, when flight data recording is enabled without any frames received.

2.2 Acquired parameters are grouped into a maximum of 253 frames by sample rate (e.g. 1 Hz). Frames do not need to be of the same size (include the same number of acquired bits) since the frame label identifies to the replay tool how to decode each frame. Sample rates from 100 Hz to 1/3 600 Hz can be used. A change in one frame does not affect any other frame. Parameters can be moved from one frame to another to level the processing load or to change sample rate.

2.3 When a frame is acquired, all parameters assigned to that frame are acquired at the same time and packed into 32-bit words. The frame is identified with a frame label and time stamp and then transferred to crash-protected memory.

3. **ARINC 767 data frame structure**

3.1 As discussed in the previous section, the ARINC 767 data frame includes multiple frames. The number and order of acquired parameters within each frame is specified for each data frame. Acquired parameters can use between one to 32 bits (the ARINC 717 12-bit limitation does not apply). Acquired parameters (e.g. 32-bit floating point parameter) can be condensed into a smaller number of bits (e.g. 14 bits) using an LSB resolution to efficiently utilize crash-protected memory.



3.2 Four example frames of differing sample rates and number of parameters are illustrated below in Figure 3-D-1. The four parameters within frame 4 are packed into a single 32-bit word with 2 bits of pad.

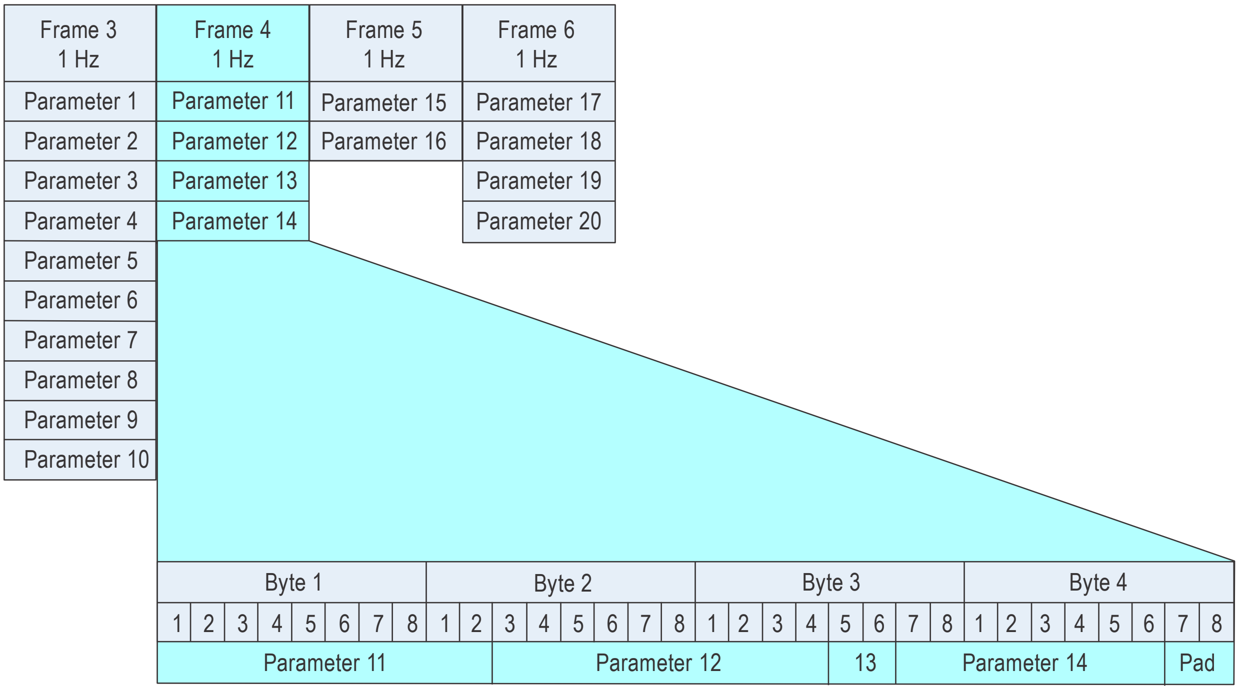


Figure 3-D-1. Example frame for four parameters in frame 4

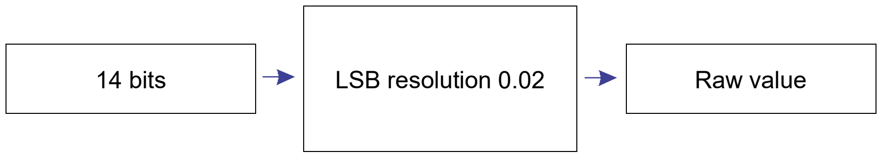
3.3 The acquisition schedule for the example frames is illustrated in Figure 3-D-2 for one second duration:

0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Frame 6 8 Hz	Frame 6 8 Hz	Frame 6 8 Hz	Frame 6 8 Hz	Frame 6 8 Hz	Frame 6 8 Hz	Frame 6 8 Hz	Frame 6 8 Hz
Parameter 17	Parameter 17	Parameter 17	Parameter 17	Parameter 17	Parameter 17	Parameter 17	Parameter 17
Parameter 18	Parameter 18	Parameter 18	Parameter 18	Parameter 18	Parameter 18	Parameter 18	Parameter 18
Parameter 19	Parameter 19	Parameter 19	Parameter 19	Parameter 19	Parameter 19	Parameter 19	Parameter 19
Parameter 20	Parameter 20	Parameter 20	Parameter 20	Parameter 20	Parameter 20	Parameter 20	Parameter 20
Frame 5 4 Hz		Frame 5 4 Hz		Frame 5 4 Hz		Frame 5 4 Hz	
Parameter 15		Parameter 15		Parameter 15		Parameter 15	
Parameter 16		Parameter 16		Parameter 16		Parameter 16	
Frame 4 2 Hz				Frame 4 2 Hz			
Parameter 11				Parameter 11			
Parameter 12				Parameter 12			
Parameter 13				Parameter 13			
Parameter 14				Parameter 14			
Frame 3 1 Hz							
Parameter 1							
Parameter 2							
Parameter 3							
Parameter 4							
Parameter 5							
Parameter 6							
Parameter 7							
Parameter 8							
Parameter 9							
Parameter 10							

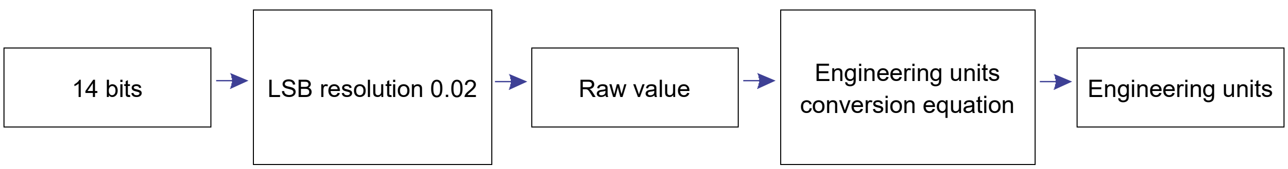
Figure 3-D-2. Example frame for one second

4. **ARINC 767 data conversions**

4.1 The flight recorder electronic documentation (FRED) per ARINC 647A describes the data frame to allow replay tools to convert the recorded binary data into raw values and engineering units. Numeric data conversions are similar to those described in section 3.13 except that up to 32 bits can be assigned to each parameter within the EAFR.



4.2 Discrete and coded parameter state values (e.g. "on", "off") are included in the FRED file to allow the replay tool to convert recorded numeric values (e.g. "1") to text (e.g. "on"). Engineering unit conversion equations, including polynomials, are included in the FRED file to allow the replay tool to perform engineering unit conversion after the conversion from binary to raw values.



4.3 The FRED file is stored within the EAFR crash-protected memory to ensure that the correct FRED file is associated with the flight data file. The FRED file eliminates data frame definition transcription errors that can occur from hard copy to replay tool.

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Chapter 4

COCKPIT VOICE RECORDER SYSTEM

4.1 COCKPIT VOICE RECORDER SYSTEM STANDARDS

4.1.1 The minimum performance standards for cockpit voice recorder systems and cockpit audio recording systems are contained in EUROCAE documents ED-112A and ED-155, respectively.

4.1.2 The provisions to fit a cockpit voice recorder system or a cockpit audio recording system are contained in Annex 6, Part I, 6.3.2 and similar provisions in Annex 6, Parts II and III. Provisions are applicable as of or will be applicable after 1 January 2020 for certain aeroplanes to be equipped with a CVR capable of retaining the information recorded during at least the last 25 hours of its operation. The operational implementation of these provisions is considered the same as for two-hour recording duration type CVRs.

4.1.3 Each part specifies channels to be recorded appropriate to the airframe type and, in the related appendices, inspection intervals (refer to Table 4-1 below and to Annex 6 for the original requirements).

Table 4-1. CVR/CARS maintenance intervals

Interval	*Action*
Prior to first flight of the day	Activate and monitor recorder system self-test or built-in test function.
One year	Inspection of recorded signal consisting of checks in accordance with Annex 6.
Two years	Inspection of recorded signal that has demonstrated a high integrity of serviceability and self-monitoring, consisting of checks in accordance with Annex 6. A two-year time period subject to approval by the State national airworthiness authority.

4.1.4 The manufacturer's maintenance instructions should be adhered to for the maintenance and servicing of components related to the CVR such as underwater locator devices attached to the CVR, alternate CVR power source and components to stop the CVR recordings after 10 minutes when the electric power is lost, if such components are not integral to the CVR.

4.2 RECOMMENDATIONS FOR MAINTENANCE INTERVALS

For maintenance intervals specified by the competent authority or cockpit voice recorder manufacturer or aircraft maintenance manual:

a) the recommendations of the CVR system installer (type certificate (TC) or supplemental type certificate (STC) holder) should be followed; or

b) if these recommendations are not comprehensive, as a minimum, time intervals should be elected by the operator which do not exceed the maximum time intervals defined in Annex 6.

4.3 AT INTERVALS NOT EXCEEDING 12 MONTHS FOR SOLID STATE CVRs

An examination of the recorded signal on the CVR should be carried out by replay 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. During the annual examination, where practicable, a sample of in-flight recordings of the CVR should be examined for evidence that the intelligibility of the signal is acceptable.

4.4 AT INTERVALS NOT EXCEEDING 24 MONTHS FOR SOLID STATE CVRs

4.4.1 An examination of the recorded signal on the CVR should be carried out by replay 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. During the annual examination, where practicable, a sample of in-flight recordings of the CVR should be examined for evidence that the intelligibility of the signal is acceptable.

4.4.2 Operators should review all their approved aircraft maintenance programmes for compliance with the above recommendations.

Note.— Without prejudice to national laws, the analysis of samples of in-flight recordings of the CVR is considered to be practicable and beneficial to identify anomalies that are not present in on-ground recordings.

4.5 REPLAY AND ANALYSIS PROCEDURES AND FACILITIES

4.5.1 The replay facility 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.

4.5.2 The recording should be played back in an area where the privacy and confidentiality of the recorded voices may be assured. Operators, contractors and entities programming and performing maintenance are reminded of the special provisions in Annex 6, Part I, Section 3.3. This may require a separate room depending on the size of the organization performing the task.

4.5.3 It is recommended to use dedicated tools to visualize the audio signal (over time, frequency domain, energy levels, etc.) so as to check if a part of the recording seems affected by an audio anomaly. The BEA Study on *Detection of Audio Anomalies on CVR Recordings* may be referred to during the analysis of the CVR audio recordings. The CVR analyst should then focus on such part of the recording instead of selecting audio samples randomly. It is indeed essential for the reliability of the CVR audio assessment that the CVR analyst focus on where there might be a quality issue. To assess the serviceability of the CVR system as configured on the aircraft, the following checks and functional tests are given as examples:

a) samples of voice communications transmitted from or received by the aircraft communications equipment at selected flight phases;

b) samples of conversation on the flight deck at selected flight phases;

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 (CAM) to ensure that it satisfactorily records all cockpit sounds;

g) each recording channel is functioning correctly and the source of information recorded on each channel is identifiable, e.g. pilot or co-pilot audio system;

h) duration of the CVR recording is consistent with the recording interval specified by the regulatory authority applicable; and

i) examples of tests and checks usually performed are described in the guidance on CVR recording inspection and may be referred to during the analysis of the CVR audio recordings.

4.5.4 The guidance on CVR inspections, dated 8 October 2018 and available on the BEA website (http://www.bea.aero), details best practices in order that the CVR recording inspections are performed in an appropriate manner, applying methods to detect potential defects thus ensuring that the CVR audio recording is of good quality.

4.6 AUDIO INTELLIGIBILITY

4.6.1 Intelligibility is a measure of the ability for a speaker familiar with the language and accent to make an accurate transcript of the communications and of synthetic voice in audio callouts, warnings and alerts.

4.6.2 A quantitative measure of intelligibility can be made by comparing the recording with a calibrated level of noise, distortion or interference. An example of a quantitative measure is the testing by using speech transmission index (STI).

4.6.3 A qualitative measure of intelligibility can be made by appropriately trained analysts listening to the recording and assessing quality of the recorded speech. An example of a quality rating scale is included in the document *Guidance on CVR recording Inspection (http://www.bea.aero)*. Another one is presented below:

CVR quality rating scale

The levels of recording quality are characterized by the following traits of the cockpit voice recorder information.

Excellent quality

Virtually all of the crew conversations could be accurately and easily understood. A qualitative intelligibility assessment may indicate only one or two words that were not intelligible. Simultaneous cockpit/radio transmissions do not obscure crew conversation.

Good quality

Most of the crew conversations could be accurately and easily understood. A qualitative intelligibility assessment may indicate several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies or momentary dropouts in the recording system or to a large number of simultaneous cockpit/radio transmissions which do not obscure crew conversation.

Fair quality

The majority of the crew conversations were intelligible. A qualitative intelligibility assessment may indicate passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information.

Poor quality

Extraordinary means had to be used to make some of the crew conversations intelligible. A qualitative intelligibility assessment may indicate fragmented phrases and conversations and may indicate extensive passages where conversations were missing or unintelligible. This type of recording is usually caused by a combination of a high cockpit noise level with a low voice signal (poor signal-to-noise ratio), or by a mechanical or electrical failure of the CVR system that severely distorts or obscures the audio information.

Unusable

Crew conversations may be discerned, but neither ordinary nor extraordinary means made it possible to develop a meaningful transcript of the conversations. This type of recording is usually caused by an almost total mechanical or electrical failure of the CVR system.

Note.— With the above quality rating scale, a signal source with the rating "excellent", "good" or "fair" should be considered as acceptable by the analyst.

4.6.4 Not only the duration of an issue is relevant but also the occurrence rate and the consequences on the intelligibility of the required signal sources should be considered as well. A phenomenon can be acceptable if it appears once or twice during a flight (the audio quality of the affected signal source could be considered "fair"). However, if the phenomenon occurs frequently resulting in unintelligible portions of recordings, the audio quality of the affected signal source should be considered as "poor". Refer to Table 4-2 below for examples of issues affecting a signal source and of the associated severity.

Table 4-2. Examples of issues affecting a signal source and of the associated severity

Issue severity	*Examples of issues*
MAJOR leading to “poor” rating for the affected signal	– One or more warning or callout is not recorded – Uncommanded interruption of the CAM signal – Unexplained variation of the CAM dynamic range – Hot mic function not operative (cf A/C CoFA) – CVR time code not available – CAM saturation (due to LF vibration) – Radio side tone is missing – One required signal source is missing from the recording (e.g. one mic signal not recorded) – Bad intelligibility of one mic source (e.g. speech through oxygen mask mic) – Quasi permanent physical saturation of a mic cell – Quasi permanent electrical saturation of a CVR channel – Mechanical and/or electrical interference providing useful data suppression – Default of CAM sensitivity – Default in the start/stop sequence
MEDIUM leading to “poor” or “fair” rating for the affected signals depending on the duration, and the occurrence rate of the issues	– Imbalance of audio event – Audio pollution generated by either the A/C or the recorder power supply – Low dynamic range of the recording on a CVR channel – Low recording level of warning and or callout – Over sensitivity of the CAM line* to hyper frequency activity (Wi-Fi, GSM**, …) – Over sensitivity of the CAM line* to ESD*** phenomenon – Over sensitivity of the CAM to air flow or conditioning noise (bleed air) – Phasing anomaly between CVR tracks – Side tone recorded with low level – Transitional saturation

* *CAM line: microphone+control or preamp unit+wiring*
** *Global system for mobile communications standard*
*** *Electrostatic discharge*

4.7 OPERATOR RESPONSIBILITIES

4.7.1 An operator’s own validation process of their CVR replays should be detailed in the company system of maintenance. This replay will be undertaken by competent staff and will be documented (refer to template in Appendix A to Chapter 4).

4.7.2 A procedure should be established that enables the operator to perform a maintenance replay of the CVR, which should highlight any deficiencies and the associated remedial actions.

4.7.3 In certain cases, an aircraft operator may lack sufficient resources to undertake CVR 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:

a) the contacting organization has the capability to replay CVRs in their approved procedures; and

b) the CVR replay report should include an assessment in accordance with these procedures.

4.7.4 The analyst should assess all CVR recordings against a quality rating scale. This quality rating scale should be provided for reference in the CVR recording inspection report.

4.7.5 For a CVR recording to be considered representative, it should contain at least:

a) taxiing (for an aeroplane); and

b) any one of the following:

1) take-off and climb up to cruise altitude;

2) descent phase from cruise altitude, approach and landing; and

3) for helicopters, hover and autorotation should be included (particular for certification process).

Otherwise, the analyst should mention in the report that a complete CVR recording inspection could not be performed. Experience shared by accident investigation authorities showed that the audio quality of a CVR recording may significantly vary depending on whether the aircraft is airborne or not.

4.7.6 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 the audio quality and intelligibility should be noted, along with any other observations made from the recording. For helicopters, if rotor speed was announced by the crew, correlation between rotor speed announcements and recorded rotor speed data should be established and recorded. In all cases, the position of the area microphone in the particular aircraft should be stated in the report.

4.7.7 Templates of test results report where dedicated function associated to each channel is evaluated are presented in Appendices B and C to Chapter 4. The report should contain a column for each channel of the recording to note the results.

4.8 COCKPIT AUDIO RECORDING SYSTEMS

4.8.1 Lightweight flight recorder systems have been developed to promote the fitment of flight recorders to smaller aircraft. Rather than being a singularly dedicated accident investigation tool, operational use of data captured by lightweight flight recorder systems is encouraged. However, in the case of lightweight combination flight recorders which include audio recording functionality, protection of these audio recordings as provided in Annex 13, Annex 6 and Annex 19 — *Safety Management* shall be observed.

4.8.2 Where the recorded information is being utilized according to the rules of exception in Annex 6 or Annex 19 as part of a safety management system or other safety enhancement activity, the level of scrutiny should be assessed for equivalence to a reasonableness check. Credit should be considered to extend the time period between scheduled maintenance actions in the light of these activities.

4.9 MANAGING RECORDING QUALITY ISSUES

4.9.1 CVR audio recording quality should be considered as unacceptable when the information required by regulations to be recorded by the CVR (as indicated by the applicable operating requirements) is unintelligible or inexplicably missing. For example, if a required source signal on a CVR channel is of poor quality and is not recorded by another channel, the CVR audio recording quality should be considered unacceptable.

4.9.2 Troubleshooting should then be performed to identify the appropriate corrective actions. To ensure their effectiveness, a CVR audio quality check should subsequently be performed.

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Appendix A to Chapter 4

EXAMPLE OF AN INSPECTION REQUEST FORM

Note.— The proposed Inspection Request Form for CVR recording inspection should be adapted based on the applicant and the inspection organization provider.

Applicant

Name:	
Date of the request:	
Reference:	

Aircraft

Type:	
Registration:	
Serial number:	
Date of first Initial Certificate of Airworthiness:	
Hot-mic function installed:	
FSK function installed:	

Test

Type of test:	
Date of removal/dump:	
CVR data download tool:	
Test/download reference:	

Recorder and CVR track assignment

Device	*Manufacturer*	*P/N*	*S/N*	*Mod dot(s)*
Recorder:				
CVR track assignment:	1: 2: 3: 4: 5:			

Complementary information of the on-board audio system

Device	*Manufacturer*	*P/N*	*EUROCAE compliancy*
CAM cockpit area microphone:			
C/U or preamplifier:			
Audio management unit:			
V/UHF:			
V/UHF if various P/N:			
Headset/boomset:			
Hand microphone:			
Oxygen mask:			

Purpose and condition of the test

Attach if necessary the test programme, flight test report, and/or other technical document.

Audio system compliancy

EUROCAE reference:	

Inspection report release

Expected date:	

Contact/person in charge

Name:	
Quality:	
Phone number:	
Email:	

Appendix B to Chapter 4

EXAMPLE OF A CVR QUALITY ASSESSMENT REPORT

Reference information: The table is to be built based on the information provided in the inspection request form.

Results

Recording channel	*1*	*2*	*3*	*4*	*5*
Function	*Captain*	*F/O*	*3rd and FSK*	*CAM*	*Mixed*
Microphones					
Hot-mic boom	N/I	N/I	N/I	–	N/I
Hot-mic mask if applicable	N/I	N/I	N/I	–	N/I
Hot-mic level	N/I	N/I	N/I	–	N/I
Telephone/PA					
Radio reception	Fair	Good	N/I	–	Bad
Radio sidetone	Good	Good	N/I	–	Fair
Interphone	Fair	Good	N/I	–	Bad
Public address	–	–	–	–	–
Warnings*	Good	Good	Fair	–	Good
Signal level	Good	Good	N/I	–	Good
Area mic					
Cockpit sounds	–	–	–	Bad	–
Warnings/call-outs	–	–	–	Bad	–
Signal level	–	–	–	Bad	–

Recording channel	*1*	*2*	*3*	*4*	*5*
Function	*Captain*	*F/O*	*3rd and FSK*	*CAM*	*Mixed*
Time signal	Good	–	–	–	Good
Start – Stop function if applicable	Good	Good	Good	Good	Good
Channel duration					
Recorder Independent Power Supply (RIPS)/Alternate power supply if applicable				**Good**	
Additional information					
File name (in native format)	Air Flying - xxx				
File name (.wav)	Air Flying _ch1	Air Flying _ch2	Air Flying _ch3	Air Flying _wb	Air Flying _mb

**May only be recorded on the CAM channel depending on the audio system design.*

REMARKS:..

It is certified that the above-mentioned recording has been evaluated in accordance with the terms of the contract/order applicable thereto and the requirements of the Certification Authority relating to the evaluation of such recordings.

SIGNED: ....

DATE: ....
for and on behalf of XXX

____

Appendix C to Chapter 4

CONTENT OF THE CVR INSPECTION REPORT

The report on the CVR audio quality check should contain:

a) information on the device/equipment and the aircraft configuration as provided in the inspection request form (Appendix A);

b) the quality rating scale used in the report;

c) the identification of the equipment used to download, replay and analyse the CVR audio files;

d) the test procedure and results with specific observation, if applicable;

e) the CVR quality assessment report (Appendix B) as a summary of the quality check; and

f) conclusion.

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Chapter 5

AIRBORNE IMAGE RECORDING SYSTEM

5.1 AIRBORNE IMAGE RECORDER SYSTEM STANDARDS

5.1.1 The minimum performance for airborne image recorder systems and airborne image recording systems are contained in EUROCAE documents ED-112A and ED-155, respectively.

5.1.2 The provisions for flight crew-machine interface recordings and/or to fit an airborne image recorder (AIR) system or lightweight airborne image recording (AIRS) system is contained in Annex 6, Parts I, II and III.

5.1.3 Each part specifies the images to be recorded appropriate to the airframe type and, in the related appendices, inspection intervals (refer to Table 5-1 below and to Annex 6 for the original requirements):

Table 5-1. AIR/AIRS maintenance intervals

Interval	*Action*
Prior to first flight of the day	Activate and monitor recorder system self-test or built-in test function.
One year	Inspection of the recorded images consisting of checks in accordance with Annex 6.
Two years	Inspection of the recorded images that has demonstrated a high integrity of serviceability and self-monitoring, consisting of checks in accordance with Annex 6. A two-year time period subject to approval by the State National Airworthiness Authority.

5.2 EXAMINATION OF RECORDED INFORMATION

5.2.1 An annual examination of the recorded images on the AIR shall be carried out by a replay of the AIR recording.

5.2.2 While installed in the aircraft, the AIR shall record test images from each aircraft source and relevant external sources to ensure that all required images meet recording quality Standards.

5.3 POST-FLIGHT EVALUATION OF RECORDINGS

5.3.1 Introduction

5.3.1.1 Following the flight testing of each new AIR installation, the recording so obtained shall be evaluated to confirm adequate quality. Similarly, it will be necessary to evaluate recordings obtained on a sampling basis from in-service flying or following cockpit modification, which may change the image environment to ensure that quality is maintained.

5.3.1.2 It is recommended that the replay equipment be located in a clean, quiet area which is sufficiently separated from other work areas to ensure the privacy of recordings. Access to the replay equipment should be restricted to authorized personnel only.

5.3.1.3 Provision should be made for the secure storage of AIR recording media and any copies made.

5.3.1.4 The replay and evaluation of recordings should be performed by personnel with adequate knowledge of AIR systems and aircraft operations and who have appropriate experience with the techniques used to evaluate recordings.

Note 1.— Accident investigation authorities may be able to provide demonstrations which would assist the training of personnel.

Note 2.— Where possible, replay personnel should be given the opportunity to accompany the flight crew on an AIR test flight in order to become familiar with the test procedure.

5.3.1.5 A test report and certification in a format acceptable to the certification authority will be required to record the observations made from the evaluation of the recording.

5.3.1.6 **Replay equipment**

The evaluation of recordings from AIR installations should involve replay equipment which would not degrade the images.

5.3.1.7 **Recording evaluation**

The recording should be checked to confirm that the required input sources are connected to the AIR system and that the 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.

5.4 TEST REPORT

5.4.1 A suitable AIR test report is shown in Table 5-2. The report may be supplemented by photographic or printed evidence obtained from selected extracts of the recording.

5.4.2 The spaces on the report, as applicable, should be annotated with brief comments on the replay image quality. Remarks on these qualitative checks such as “good” or “not good” should be defined in the procedures manual.

Table 5-2. Example of AIR test report

XXX AVIONICS
Municipal Road
TOONVILLE

CERTIFICATE NO.

TEST CERTIFICATE

AIRCRAFT IMAGE RECORDER — FLIGHT TEST EVALUATION

AIRCRAFT TYPE:……………………. REG:……………….……..……… OPERATOR:……………….………

CVR TYPE:…………………………… SERIAL NO.:…………………..…..… FLIGHT NO.:……………….…………

Image recording quality check	
Spatial resolution	“Good” or “Not good”
Field of view	“Good” or “Not good”
Camera sensitivity	“Good” or “Not good”
Contrast	“Good” or “Not good”
Distortion	“Good” or “Not good”
Digital artefacts	“Good” or “Not good”

REMARKS: ………
……….
……..
……

It is certified that the above-mentioned recording has been evaluated in accordance with the terms of the contract/order applicable thereto and the requirements of the certification authority relating to the evaluation of such recordings.

SIGNED:…………………………………………………….. DATE:……………………………………………………..

for and on behalf of XXX Avionics

Organization approval reference ……………………………………………………

5.5 MAINTENANCE PRACTICES

5.5.1 General

5.5.1.1 The maintenance tasks required to ensure the continued serviceability of the installed flight crew-machine interface recordings system will depend on the extent of monitoring built into this system. The flight crew-machine interface recordings system installer (TC or STC holder) should perform an analysis of the system to identify those parts of the system which, if defective, would not be readily apparent to the flight crew or maintenance personnel. Appropriate inspections and functional checks, together with the intervals at which these would need to be performed need to be established as indicated by the analysis.

5.5.1.2 The specified checks need to include verification of system performance, where appropriate.

5.5.1.3 A flight recording should be replayed at specified intervals to reveal defective equipment and to indicate essential maintenance actions. Where a replay evaluation indicates an aircraft system defect, appropriate corrective action should be initiated.

5.5.1.4 Any inspection or test requirements specified by equipment manufacturers should be observed, e.g. battery checks of the underwater locator beacon.

5.6 RECORDING EVALUATION

5.6.1 Samples of an in-flight recording during selected flight phases should be replayed and assessed for quality. Table 5-2 provides guidance for the evaluation of such recordings.

5.6.2 An airborne flight crew-machine interface recording systems should be considered unserviceable if the recording duration is less than required or if there is a period of poor quality images.

5.7 PRIMARY MAINTENANCE TASKS

Table 5-3 shows the primary maintenance tasks for the installed flight crew-machine interface recording system. Inspection periods should be established on the basis of the system analysis discussed in paragraph 5.5.1.1.

5.8 AIRBORNE IMAGE RECORDING SYSTEM

5.8.1 Lightweight flight recorder systems have been developed to promote the fitment of flight recorders to smaller aircraft. Rather than being a singularly dedicated accident investigation tool, operational use of data captured by lightweight flight recorder systems is encouraged. However, in the case of lightweight combination flight recorders which include image recording functionality, protection of these image recordings as provided in Annex 13, Annex 6 and Annex 19 shall be observed.

5.8.2 Where the recorded information is being utilized according to the rules of exception in Annex 6 or Annex 19 as part of a safety management system or other safety enhancement activity, the level of scrutiny should be assessed for equivalence to a reasonableness check. Credit should be considered to extend the time period between scheduled maintenance actions in the light of these activities.

Table 5-3. Maintenance tasks and intervals

Item	*Equipment*	*Task*	*Maximum interval*	*Interpretation*
1	Aircraft flight crew-machine interface recordings system	Operational check	Daily (pre-flight and/or post-flight).	Confirm serviceability using TEST function on AIR controller or check “no-fail” indication for built-in test.
2	Aircraft flight crew-machine interface recordings system	Check/ functional test	Not exceeding six months elapsed time.	Inspect installation. Confirm proper functioning of the inhibit logic for the erase function.
3	Aircraft image recorder	Check/replay	Not exceeding interval stated by the vendor.	Remove recorders for inspection and test as required by the Component Maintenance Manual. *Note.— The recording stored on the media prior to the removal should be evaluated.*
4	Aircraft image recorder	Check in accordance with criteria and procedures agreed with the regulatory authority	One year, or up to a maximum of two years if approval from the appropriate regulatory authority has been obtained for AIR systems that have demonstrated a high integrity of serviceability self-monitoring.	Remove AIR immediately post-flight. Replay and evaluate the quality of the in-flight recording.

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Chapter 6

DATA LINK RECORDING SYSTEM

6.1 DATA LINK RECORDING SYSTEM STANDARDS

6.1.1 The minimum performance for data link recorder (DLR) systems and data link recording systems (DLRS) are contained in EUROCAE documents ED-112A and ED-155, respectively.

6.1.2 The requirement to fit a DLR system or lightweight DLRS are contained in Annex 6, Parts I, II and III.

6.1.3 Each part specifies the parameters to record that are appropriate to the airframe type (Appendix to Chapter 6 refers) and in the related appendices inspection intervals (refer to Table 6-1 below and to Annex 6 for the original requirements).

Table 6-1. DLR/DLRS maintenance intervals

Interval	*Action*
Prior to first flight of the day	Activate and monitor recorder system self-test or built-in test function.
Two years	Inspection of recorded messages consisting of checks in accordance with Annex 6.
Four years	Inspection of recorded messages that has demonstrated a high integrity of serviceability and self-monitoring, consisting of checks in accordance with Annex 6. A four-year time period subject to approval by the State National Airworthiness Authority.

6.2 POST-FLIGHT EVALUATION OF RECORDINGS/DLR SYSTEM DOCUMENTATION

6.2.1 Introduction

Following the flight testing of each recorder system installation, the recording so obtained should be evaluated to confirm adequate quality.

6.2.2 Replay equipment

Means should be provided to retrieve and decode recorded messages obtained via a digital data link. Similarly, a means to retrieve timing signals should be provided.

6.2.3 Recording evaluation

Proper recording of a data link message should be verified and correlated to announcements recorded by the flight crew.

6.2.4 Test report

The report may be supplemented by printing evidence obtained from selected extracts of the recording. The spaces on the report should, as applicable, be annotated with brief comments on the replay signal quality.

6.3 MAINTENANCE PRACTICES

6.3.1 General

6.3.1.1 The maintenance practices contained in this manual (and related EUROCAE documents) are intended to ensure continued serviceability of DLR systems and are intended as guidance for original equipment manufacturer (OEMs) and DLR system design and STC holders in the creation of maintenance practices for their systems.

6.3.1.2 The maintenance tasks required to ensure the continued serviceability of the installed DLR system will depend on the extent of monitoring capability built into the DLR system. The DLR system installer (TC or STC holder) should perform an analysis of the DLR system to identify those parts of the system which, if defective, would not be readily apparent to the flight crew or maintenance personnel. Appropriate inspections and functional checks as indicated by the analysis, together with the intervals at which these should be performed, need to be established.

6.3.1.3 The specified checks need to include the verification of system performance, where appropriate.

6.3.1.4 The equipment needs to include a continuous and exhaustive monitoring of the data link recording function (e.g. by continuous BITE) that provides failure messages to the aircraft maintenance system or to the cockpit information system (usually warning display).

6.3.1.5 If such a monitoring cannot be implemented, then a data link recording download and analysis should be performed at intervals of no greater than two years or up to a maximum of four years if approval from the appropriate regulatory authority has been obtained at the time of certification of the type for DLR systems that have demonstrated a high integrity of serviceability self-monitoring.

6.3.2 Recording evaluation

Samples of in-flight recording during selected flight phases should be replayed and assessed for integrity. Section 6.3 provides general guidance for the evaluation of similar recordings. Data link recorder systems should be considered unserviceable if the recording duration is less than required, if one or more messages are corrupted or not recorded.

6.3.3 Primary maintenance tasks

Table 6-2 below shows the primary maintenance tasks for the installed DLR system. Inspection periods should be established on the basis of the DLR system analysis discussed in section 5.4.

6.4 DATA LINK RECORDING SYSTEM

6.4.1 Lightweight flight recorder systems currently do not include data link recording functionality, besides utilizing the image recording functionality to record what data link messages were displayed. These lightweight recorder systems would thus be maintained accordingly.

Table 6-2. Maintenance tasks and intervals

Item	*Equipment*	*Task*	*Maximum interval*	*Interpretation*
1	DLR system	Check in accordance with criteria and procedures agreed with the regulatory authority	Two years, or up to a maximum of four years if approval from the appropriate regulatory authority has been obtained for DLR systems that have demonstrated a high integrity of serviceability self-monitoring.	Confirm correct recording of digital data link messages: Within the last 90 minutes of a designated flight, have the flight crew speak out at least three data link messages sent and at least three data link messages received. After the flight, read out the DLR and the CVR and check that the recorded data link messages are consistent with the CVR recording.
2	DLR	Check/replay	Not exceeding interval stated by the vendor.	Remove recorders for inspection and test as required by the Component Maintenance Manual. *Note.— The recording stored on the media prior to the removal should be evaluated.*

Appendix to Chapter 6

DATA LINK RECORDING TABLE

DATA TO BE RECORDED

The material in section 6.3.1 and Table 6-App-1 is to be considered as guidance material only and as a means of compliance with the MASPS ED-93. Table 6-App-1 lists the function and states if the appropriate data should be recorded. The minimum list of applications and services required to be recorded is provided in Annex 6, Part I, Appendix 8, Table A8-2 and similar provisions in Annex 6, Parts II and III.

Table 6-App-1. Data link recording requirements

Item	*Air traffic service type*	*Air traffic service description*	*Recording content*
1	Data link initiation	This includes any applications used to log on to or initiate data link service. In FANS-1/A and ATN, these are ATS facilities notification (AFN) and context management (CM) respectively.	C
2	Controller/pilot communication	This includes any application used to exchange requests, clearances, instructions and reports between the flight crew and controllers on the ground. In FANS-1/A and ATN, this includes the CPDLC application. It also includes applications used for the exchange of oceanic (OCL) and departure clearances (DCL) as well as data link delivery of taxi clearances.	C
3	Addressed surveillance	This includes any surveillance application in which the ground sets up contracts for delivery of surveillance data. In FANS-1/A and ATN, this includes the automatic dependent surveillance — contract (ADS-C) application. Where parametric data are reported within the message they shall be recorded unless data from the same source are recorded on the FDR.	C
4	Flight information	This includes any service used for delivery of flight information to specific aircraft. This includes, for example, data link aviation weather report service (D-METAR), data link-automatic terminal service (D-ATIS), digital Notice to Airmen (D-NOTAM) and other textual data link services.	C
5	Aircraft broadcast surveillance	This includes elementary and enhanced surveillance systems, as well as automatic surveillance dependent — broadcast (ADS-B) output data. Where parametric data sent by the aeroplane are reported within the message they shall be recorded unless data from the same source are recorded on the FDR.	M*

Item	*Air traffic service type*	*Air traffic service description*	*Recording content*
6	Aeronautical operational control data	This includes any application transmitting or receiving data used for aeronautical operational control purposes (per the ICAO definition of operational control).	M*

Key:
- C: Complete contents recorded.
- M: Information that enables correlation to any associated records stored separately from the aeroplane.
- *: Applications to be recorded only as far as is practicable given the architecture of the system.

Chapter 7

UNIQUE FLIGHT RECORDER CHARACTERISTICS

7.1 COMBINED FLIGHT RECORDER (COMBI)

7.1.1 Combined flight recorder design allows for two or more flight recorder functions to be performed within a single recording unit. For example, data link and cockpit voice recorder information may be stored in a single recording unit.

7.1.2 Maintenance of a single function should be performed with reference to the appropriate chapter in this manual. For example, FDR function maintenance may reference Chapter 3.

7.1.3 The design of the recording unit must ensure that the loss of a function does not impair the operation of another function. The design also requires that the operation of each function does not create interference or corruption to another function.

7.1.4 Therefore, when assessing recorded information, it is essential that the source recording unit be identified. It is also important, when two combination flight data and cockpit voice recorders are installed (typically one at the front and one at the rear), to identify from which position in the aircraft the recording unit was removed.

7.1.5 Procedures should alert an operator to perform special analysis when reading out the information downloaded from a combined recorder

7.2 AUTOMATIC DEPLOYABLE FLIGHT RECORDER (ADFR)

7.2.1 An ADFR unit may perform a single flight recorder function, flight data recorder only or more flight recorder functions. An ADFR unit may combine the functions of an FDR and CVR.

7.2.2 When an ADFR unit is combining two or more flight recorder functions, the deployable information should be analysed in the same manner as for combined flight recorders.

7.2.3 On the ground, the ground staff could be injured or the recorder could be inadvertently damaged during maintenance, cleaning operations, painting operations or application of anti-icing fluid on the aircraft surface. There should be means and procedures to protect the dedicated crash sensors from ground operations, as recommended by ED-112A. On this issue, the flight recorder system installer is responsible for defining maintenance instructions which address the risk of injuries to passengers and ground staff and the effect of ground operations on the detection sensors.

7.2.4 Possible damage caused to the recorder, its sensors or its deployment feature by exposure to climatic conditions (temperature variations, rain, ice, lightning strikes) should be taken into account. The experience of air forces is limited with regards to the long-term influence of climatic factors because usually military aircraft are flown less during their life cycle. On the contrary, commercial aircraft are intensively used, therefore much more exposed to climatic factors.

7.2.5 An ADFR system also includes a deployment mechanism. Maintenance of the deployment mechanism should be addressed according to the manufacturers' maintenance instructions.

7.2.6 An ADFR system can include an emergency locator transmitter (ELT). Maintenance of the ELT should be addressed according to the manufacturers' maintenance instructions.

7.2.7 Specifications relating to ELT systems are contained in Annex 10 — *Aeronautical Telecommunications*, Volume III — *Communication Systems*, Part II — *Voice Communication Systems*, Chapter 5.

Note.— Special considerations and maintenance procedures related to ELT systems are also contained in Annex 10.

— END —

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