



ICAO

Doc 10104

Manual on Flight Recorder System Maintenance (FRSM)

First Edition, 2020



Approved by and published under the authority of the Secretary General

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Published in separate English, Arabic, Chinese, French, Russian
and Spanish editions by the
INTERNATIONAL CIVIL AVIATION ORGANIZATION
999 Robert-Bourassa Boulevard, Montréal, Quebec, Canada H3C 5H7

For ordering information and for a complete listing of sales agents
and booksellers, please go to the ICAO website at www.icao.int

First edition, 2020

Doc 10104, *Manual on Flight Recorder System Maintenance (FRSM)*

Order Number: 10104

ISBN 978-92-9258-883-0

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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.

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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:

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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.

Maintenance¹. 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.

1. Applicable until 4 November 2020.

Maintenance². 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 manual¹. 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	<i>Manual on Flight Data Analysis Programmes (FDAP)</i>
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	<i>Safety Management Manual</i>
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*

1. The following information is provided for informational purposes only and does not constitute a recommendation or endorsement of any product or service by the ICAO. The user is responsible for ensuring that the information is accurate and up-to-date.

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 6.3.5.3¹, refers to Appendix 8 for continued serviceability;
- b) Part II, Amendment 36, section 2.4.16.4.4², refers to Appendix 2.3 for continued serviceability; and
- c) Part III, Amendment 22, section 4.7.4.3³, 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.

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

<i>Interval</i>	<i>Action</i>
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.

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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.