The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Equipement de l'Aviation Civile

MINIMUM OPERATIONAL PERFORMANCE SPECIFICATION FOR

LIGHTWEIGHT FLIGHT RECORDING SYSTEMS

ED-155

July 2009

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SECTION 1

GENERAL BACKGROUND

CHAPTER 1-1

INTRODUCTION

1-1.1 PURPOSE AND SCOPE

This document defines the minimum specification to be met for aircraft required to carry lightweight flight recording systems which may record aircraft data, cockpit audio, airborne images or data-link messages in a robust recording medium primarily for the purposes of the investigation of an occurrence (accident or incident). It is applicable to robust on-board recording systems, ancillary equipment and their installation in aircraft.

This document can also be used to give guidance to manufacturers intending to develop or install lightweight flight recording systems which maybe used for or other purposes such as flight training, flight data monitoring.

NOTE: *It is not the intent of this MOPS to provide replacement or acceptable alternatives for the ED-112 specification.*

1-1.1.1 General

This document responds to a need for improved recording of vital information on small aircraft needed for aviation safety investigations. This document defines recording functions (aircraft data, cockpit audio, airborne images and data-link) as individual Parts along with a common section, applicable to all Parts. Parts may be revised independently of each other and independently of the main body of this document.

1-1.1.2 Description of Content

This document is divided in to three sections, and four parts, as shown in Figure 1-1.1.

Section 1 describes typical equipment applications and operational objectives. Background material and accident/incident investigation considerations are included together with a description of the recording systems. Definitions and abbreviations essential to proper understanding of this document are provided.

Section 2 defines the requirements that are common to all robust recording systems.

Section 3 defines the requirements that are specific to deployable recorders.

Part I defines the requirements that are specific to Cockpit Audio Recording Systems.

Part II defines the requirements that are specific to Aircraft Data Recording Systems.

Part III defines the requirements that are specific to Airborne Image Recording Systems.

Part IV defines the requirements that are specific to Data-Link Recording Systems.

All flight recording systems shall be designed to meet the criteria of Sections 1 and 2 plus the relevant function specific section(s) and Parts.

1-1.2 APPLICATION

1-1.2.1 Cockpit Audio Recording System (Part I of this document)

The Cockpit Audio Recording System (CARS) records the acoustic environment of the cockpit and may include voice communications between pilots, voice communications transmitted from or received in the aircraft by radio, and voice communications of pilots in the cockpit.

1-1.2.2 Aircraft Data Recording System (Part II of this document)

The Aircraft Data Recording System (ADRS) records parameters necessary to accurately determine the aircraft movement. The specific parameters required will depend upon aircraft complexity, data sources available on the aircraft, and the need to record certain essential parameters.

1-1.2.3 Airborne Image Recording System (Part III of this document)

The Airborne Image Recording System (AIRS) records images of the cockpit environment and may include control inputs, external views, instruments and control panels.

1-1.2.4 Data-Link Recording System (Part IV of this document)

The Data-Link Recording System (DLRS) records those messages that are relayed over a digital data-link (rather than by voice communication) and which authorise, or control directly or indirectly, the movement of the aircraft.

1-1.2.5 Multi-Function Recording

It is acceptable to record audio, data, images and data-link, or a combination of two or more of these functions in a single memory module in order to comply with this MOPS.

1-1.3 TECHNICAL BACKGROUND

1-1.3.1 Units of Measurement

The measurements are expressed, where appropriate, in SI units.

1-1.4 "SHALL" AND "SHOULD" PHRASES

a. "Shall"

The use of the word "Shall" indicates a mandatory criterion to comply with this specification and no alternative may be applied.

b. "Should"

The use of the word "Should" indicates that the criterion is recommended but not mandatory to comply with this specification.

1-1.5 COMMON DEFINITIONS AND ABBREVIATIONS

The definitions and abbreviations of ICAO Annex 5, Annex 6 and Annex 10 are applicable.

1-1.5.1 Definition of Terms

The following definitions are provided for the terms that are used in this document.

AAC	The ICAO definition of aeronautical administrative communication (AAC) is communication used by aeronautical operating agencies related to the business aspects of operating their flights and transport services. This communication is used for a variety of purposes, such as flight and ground transportation, bookings, deployment of crew and aircraft or any other logistical purposes that maintain or enhance the efficiency of overall flight operation. (Annex 10, Part III). NOTE: The airlines use the term airline operational communication (AOC) for this type of communication. ICAO uses the abbreviation "AOC" for different purposes. See below. This document uses the ICAO meanings for these terms.
Airborne Image Recording System	An airborne image recording system (AIRS) is a device that uses an image sensor(s) to collect and record visual information from various parts of the aircraft.
Aircraft Data Recording System	An aircraft data recording system (ADRS) is a device or devices that use a combination of data providers to collect and record parameters that reflect the state and performance of an aircraft.
AOC	The ICAO definition of aeronautical operational control (AOC) is communication required for the exercise of authority over the initiation, continuation, diversion or termination of flight for safety, regularity and efficiency reasons (Annex 10, Part III).

APC	Aeronautical passenger communication (APC) is data-link communication relating to the non-safety audio and data services to passengers and crew members for personal communication.
Approval	An act or instance of expressing a favourable opinion or giving formal or official sanction.
ATSC	The ICAO definition of air traffic service communication (ATSC) is communications related to air traffic services including air traffic control, aeronautical and meteorological information, position reporting and services related to safety and regularity of flight. This communication involves one or more air traffic service administrations. This term is used for purposes of address administration. (Annex 10, Part III).
ATC	Air Traffic Control. In this context, the use of safety-related data-link communication for the purpose of: a Preventing collisions between aircraft and, on the manoeuvring area, between aircraft and obstructions; b Expediting and maintaining an orderly flow of traffic.
ATM	Air Traffic Management. A system consisting of a ground and air part, to ensure the efficient and safe movement of aircraft during all phases of operation. The system includes equipment, people and procedures.
ATS	Air Traffic Services. A generic term meaning variously, flight information service, alerting service, air traffic advisory service, air traffic control service (area control service, approach control service or aerodrome control service).
Camera	Within this document includes thermal imagers, image sensors and other electronic pick-up devices.
Certification	Legal recognition by a certification authority that a product, service, organisation or person complies with the applicable requirements. Such certification comprises the activity of technically checking the product, service, organisation or person and the formal recognition of compliance with the applicable requirements by issue of a certificate, licence, approval or other documents as required by national laws and procedures. In particular, certification of a product involves: a the process of assessing the design of a product to ensure that it complies with a set of standards applicable to that type of product so as to demonstrate an acceptable level of safety, b the process of assessing an individual product to ensure that it conforms with the certificated type design, c the issue of a certificate required by national laws to declare that compliance or conformity has been found with applicable standards in accordance with items (a) or (b) above.
Certification Authority	The organization or person responsible within the state or country concerned with the certification of compliance with applicable requirements.
Channel	A path that allows a signal to be transmitted or processed in a deterministic manner independently of other signals.
CNS	Communications, Navigation and Surveillance. The way in which enhanced capabilities of satellite-based navigation and digital data-link communication systems will permit the next generation of ATM systems to combine the features of ADS and CPDLC with the conventional ATC functions.
Cockpit Audio Recording System	A Cockpit Audio Recording System (CARS) is a device that uses a combination of microphones and other audio and digital inputs to collect and record the aural environment of the cockpit and communications to, from and between the pilots.

Correlation	The parallel relationship of two or more corresponding events.
Corrupted Data/Record	Any data item or record which has been altered in a way other than the one intended by design.
Crash	Refer to "Reportable Accident".
Crew member	A person assigned to perform duties in an aircraft during flight.
Data-link	Aeronautical two-way data communications.
Data-Link Recording System	A Data-Link Recording System (DLRS) is a device that records those messages whereby the flight path of the aircraft is authorised, controlled directly or indirectly, and which are relayed over a digital data-link rather than by voice communication.
Deployable Recorders	A deployable recorder is any robust recording system (ADRS, CARS or other) which is designed to be automatically separated from the aircraft only in the event of an accident.
Down-link	Transmission from air to ground.
Download	Means of copying the digital data (also known as “raw” data) stored in the robust memory module for replaying at a later time.
Flight Recording System	Any type of recording system installed in the aircraft for the purpose of complementing accident/incident investigation or flight analysis.
Follow-on Installation	A production series installation performed in accordance with a previously certified configuration (e.g. a follow-on from a Type Certificate (TC), Supplemental Type Certificate (STC) or Major Modification).
Incident	Any fortuitous or unexpected event, not being a reportable accident, by which the safety of an aircraft or any person is threatened.
Initial Installation	The installation for initial certification of the recording system.
Interconnection Harness	The electrical wiring that connects one system functional element to another e.g. between a robust memory module and the flight recording system interface electronics.
Interphone	An audio system that enables crew members to communicate with each other in the cockpit or with other personnel elsewhere on the aircraft.
Long term RMS	A signal that remains constant for a period of several seconds.
Maintenance	The ongoing process of inspections, servicing, modification and repair throughout the lifetime of an aircraft needed to ensure that the aircraft remains in compliance with the certificated type design and consistent with a high standard of safety; this includes modifications made mandatory by the authorities.
Memory Device	The smallest separate physical element in which data can be stored and recovered (e.g. chips).
Memory Module	The unprotected assembly containing the memory devices used to retain the recorded data.
Nominal	Value commonly used and considered between the minimal and maximal values.
Operator	A person, organisation or enterprise engaged in or offering to engage in an aircraft operation.
Recording	The act of making certain data persistent, with a view to subsequent replay or analysis.
Replay	The act of reconstructing the recorded situations/scenarios.

Reportable Accident

As defined by ICAO, an occurrence associated with the operation of an aircraft which takes place between the time when any person boards the aircraft with the intention of flight and such time as all persons have disembarked there from, in which:

a any person suffers death or serious injury while in or upon the aircraft or by direct contact with any part of the aircraft (including any part which has become detached from the aircraft) or by direct exposure to jet blast, except when the death or serious injury is from natural causes, is self inflicted or is inflicted by other persons or when the death or serious injury is suffered by a stowaway hiding outside the areas normally available in flight to the passengers and crew members of the aircraft; or

b the aircraft incurs damage or structural failure, other than:

1) engine failure or damage, when the damage is limited to the engine, its cowling or accessories,

2) damage limited to propellers, wing tips, antennae, tyres, brakes, fairings, small dents or punctured holes in the aircraft skin which adversely affects its structural strength, performance or flight characteristics and which would normally require major repair or replacement of the affected component, or

c the aircraft is missing or is completely inaccessible.

Retrieval

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

Robust Memory Module

The protected enclosure containing the memory module(s).

Robust Recorder

The protected part of the flight recording system which comprises an aircraft-mountable enclosure containing the memory module and which may contain other ancillary electronics.

Segregation

The physical separation of memory devices within a recording system robust module.

Sidetone

Output audio level control (through the transceiver and interphone (including the sound of the speaker's voice and background noise as picked up by the microphone and received audio) reproduced in the speaker's own head set.

Simulation

The use of a laboratory-installed system of avionic components (‘test bench’) representative of the aircraft in which the recording 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.

Software

Computer programs and, possibly, associated documentation and data pertaining to the operation of a computer system.

Solid-State

An electronic device that is capable of performing a function without use of moving parts, using semiconductor material or similar.

Sound Pressure Level

In decibels (dB), the Sound Pressure Level is 20 times the logarithm to the base 10 of the ratio of the pressure of this sound to the reference pressure. The reference pressure is 20 µPa, and shall be explicitly stated along with the Sound Pressure Level, such as: _dB above 20 µPa.

Synchronisation

A technique to align two independent events to a common point in time.

Telephone	Audio reception (radio or interphone)
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.
Timebase	A signal which provides the reference time for other recorded signals.
Timescale	A defined scale to be used in relation to the timebase signal.
Up-link	Transmission from ground to air.
Volume control setting	Channel gain level or equivalent.

1-1.5.2 Abbreviations

AAC	Aeronautical Administrative Communication
AC	Alternating Current/Advisory Circular
ACMS	Aircraft Condition Monitoring System
ADRS	Aircraft Data Recording System
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AF	Audio Frequency
AFN	ATS Facility Notification
AGC	Automatic Gain Control
AIRS	Airborne Image Recording System
ANSI	American National Standards Institute
AOC	Aeronautical Operational Control
APC	Aeronautical Passenger Communication
ARINC	ARINC (Aeronautical Radio Inc.)
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
ATSU	Air Traffic Services Unit
BITE	Built-in Test Equipment
Btu	British Thermal Units
C	Celsius
CARS	Cockpit Audio Recording System
CM	Context Management
CMS	Condition Monitoring System / Central Maintenance System
CMU	Communications Management Unit
CNS	Communications, Navigation and Surveillance
CPDLC	Controller / Pilot Data-Link Communications
D-ATIS	Digital Automatic Terminal Information Services
D-OTIS	Data-link Operational Terminal Information Services
dB	Decibels

DC	Direct Current
DCL	Departure Clearance
DL	Data-Link
DLIC	Data-Link Initiation Capability
DLRS	Data-Link Recording System
EIRP	Effective Isotropic Radiated Power
ELT	Emergency Locator Transmitter
EPR	Engine Pressure Ratio
EUROCAE	European Organisation for Civil Aviation Equipment
FANS 1/A	Future Air Navigation Systems for Boeing and Airbus aircraft
FLIRECP	Flight Recorder Panel (of ICAO)
FMS	Flight Management System
FRED	Flight Recorder Electronic Documentation
ft	Feet
g	Gravitational Acceleration
GPS	Global Positioning System
HF	High Frequency (3-30 MHz)
Hz	Hertz
ICAO	International Civil Aviation Organization
IEC	International Electrotechnical Commission
ILS	Instrument Landing System
in	Inches
kg	Kilograms
kHz	Kilohertz
kN	Kilonewtons
kPa	Kilopascals
kt	Knots
kW	Kilowatts
L	Left
lb	Pounds
LSB	Least Significant Bit
m	Metres
m/s	Metres per second
MASPS	Minimum Aviation System Performance Specification
mb	Millibars
MEMS	Micro Electromechanical Systems
mm	Millimetres
Mode-S	Mode Selective
MOPS	Minimum Operational Performance Specification
ms	Milliseconds

N1	Fan Speed
NF	Free Power Turbine Speed
NG	Gas Generator Speed
NM	Nautical Miles
NP	Propeller Speed
NR	Rotational Speed
OCL	Oceanic Clearances
Pa	Pascal
PA	Public Address
PCM	Pulse Code Modulation
ppm	Parts per million
PTT	Push To Talk
R	Right
rms	Root Mean Square
RPM	Revolutions Per Minute
RTCA	RTCA Inc.
s	Seconds
SAE	Society of Automotive Engineers
SARPs	Standard and Recommended Practices
SATCOM	Satellite Communications
SNR	Signal-to-Noise Ratio
SPL	Sound Pressure Level
TCAS	Traffic Collision Avoidance System
THD	Total Harmonic Distortion
UTC	Universal Time Co-ordinated
V	Volts
VHF	Very High Frequency (30-300 MHz)

1-1.6 LIST OF REFERENCE DOCUMENTS

ARINC Specification 647A - Flight Recorder Electronic Documentation (FRED)

EUROCAE ED-12B/RTCA DO-178B - Software Considerations in Airborne Systems and Equipment Certification

EUROCAE ED-14F/RTCA DO-160F - Environmental Conditions and Test Procedures for Airborne Equipment

EUROCAE ED-62 - Minimum Operational Performance Specification for Emergency Locator Transmitter

EUROCAE ED-78A/RTCA DO-264 - Guidance Material for the Establishment of Data Link supported ATS Services

EUROCAE ED-93 - Minimum Aviation Systems Performance Specification for CNS/ATM Message Recorder Systems

EUROCAE ED-112 - Minimum Operational Performance Specification for crash protected airborne recorder systems

ICAO International Standards and Recommended Practices - Operation of Aircraft, ANNEX 6, Parts I, II and III

ICAO SARPS - CNS/ATM Package 1 "Manual of Technical Provisions for the ATN" - ICAO Doc 9705 - AN956 - 1998

IEC 225 - 3rd Octave Filters (1966)

IEC 225 - Octave, Half Octave and Third Octave Band Filters Intended For The Analysis Of Sounds And Vibrations (1966)

IEC 651- Sound Level Meters (1979)

RTCA DO-214 - Audio Systems Characteristics and Minimum Operational Performance Standards for Aircraft Audio Systems and Equipment

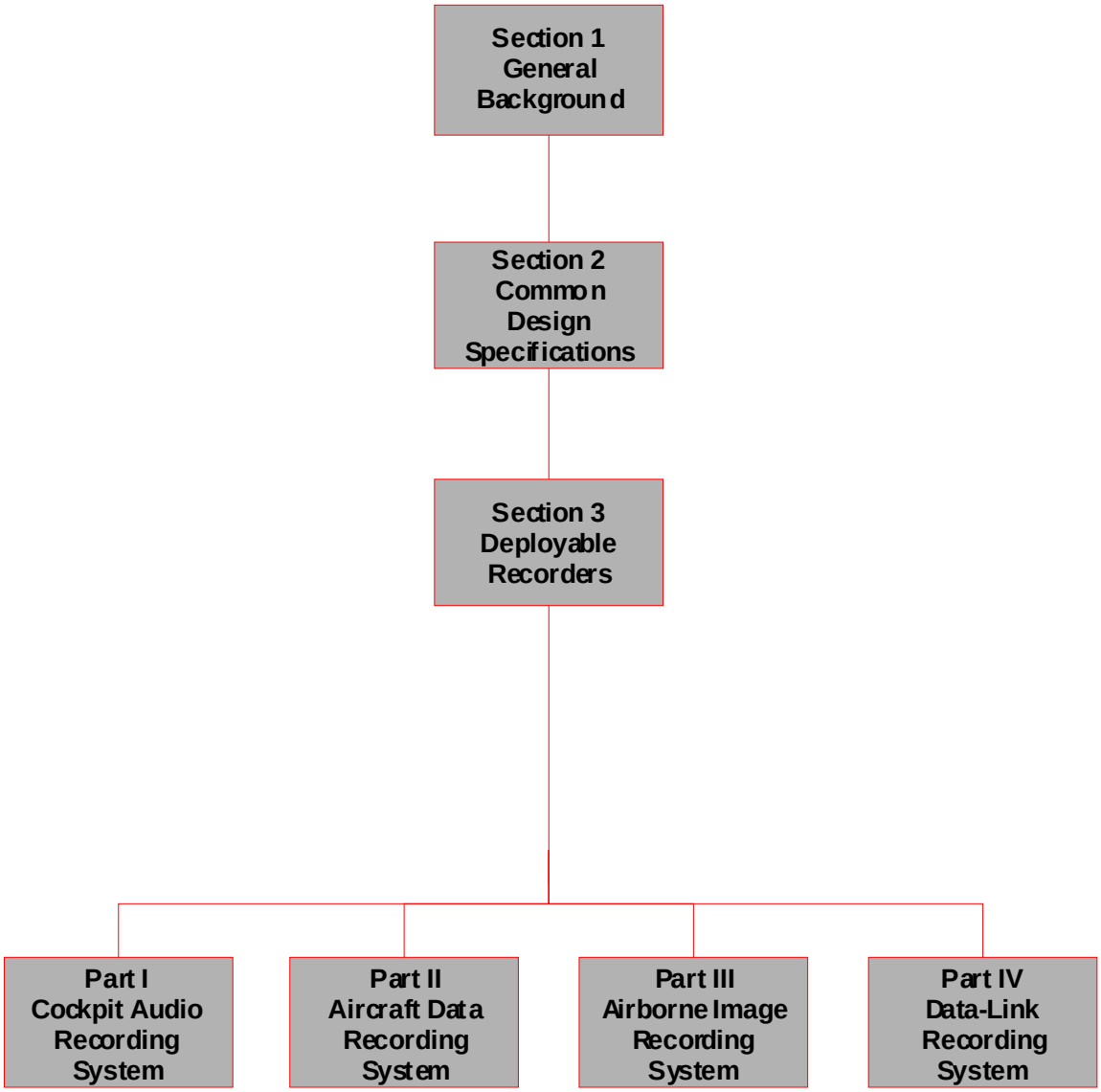


FIGURE 1-1.1: ORGANISATION OF DOCUMENT

SECTION 2

COMMON DESIGN SPECIFICATIONS

CHAPTER 2-1

GENERAL

2-1.1 INTRODUCTION

This chapter establishes the design considerations and general specifications for the equipment specific to lightweight flight recording systems.

2-1.2 RECORDING SYSTEM TECHNOLOGY

The flight recording system shall use a digital method of recording. Magnetic tape, wire and photographic methods shall not be used.

Compliance with this section will ensure that recording systems will perform their function under the conditions encountered in aircraft operations.

2-1.3 AIRWORTHINESS AND CERTIFICATION

2-1.3.1 Safety

The flight recording system equipment shall not, under normal or fault conditions, impair the airworthiness of the aircraft in which it is installed. Particular attention shall be directed to the needs of flight critical systems to ensure appropriate physical and electrical segregation of the information sources at the recording system interface.

2-1.3.2 Maintenance

The maintenance tasks required to ensure the serviceability and continued airworthiness of the flight recording systems shall be established by the equipment manufacturers and the equipment installers. The maintenance requirements for specific types of flight recording system are discussed in the relevant chapters of this document.

2-1.3.3 Flammability

Except for small quantities of materials used for heat insulation or dissipation (such as ablative paints and thermo-chemical compounds) and small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials used shall be self-extinguishing.

2-1.3.4 Documents for Compliance with this Specification

The following documents shall be made available to the accident investigation authority:

To establish compliance of the recorder with this specification:

a Instructions which would enable an accident investigation authority to obtain or manufacture any special tools or interface equipment required for the retrieval of the recorded information,

b Details of the procedures to be followed for retrieval of the recorded information from an undamaged recording system,

c Details of the procedures to be followed for retrieval of the recorded information from any memory device used within the robust memory module removed from a crash damaged recording system, including details on how data is organised in the memory,

To establish compliance of the installation with this specification:

d Interface documentation, including conversion and logic data for reproduction of the original information.

The certification authority should involve the relevant accident investigation authority in the assessment of the above documents. The assessment should confirm that

suitable equipment and information will be readily available to the accident investigation specialist to allow retrieval of the recorded information in a timely manner.

The information provided should enable the accident investigators to produce, within 24 hours of receipt of an undamaged recording medium, the material necessary to support their investigations.

2-1.4 MONITORING OF PROPER OPERATION

There shall be aural or visual means for pre-flight checking the flight recording system(s) for proper recording of the information in the recording medium.

The monitor(s) shall operate throughout the flight. However, an indication of in-flight failure may be suppressed until the aircraft has completed its flight.

NOTE: *An acceptable means of compliance would be to provide system status monitor(s) and built-in test functions which would detect and indicate a failure of the flight recording system due to any of the following:*

a. Loss of system electrical power,

b. Failure of the acquisition and processing equipment,

c. Failure of the recording medium,

d. Failure of the recording system to store the information in the recording medium as shown by checks of the recorded material including, if reasonably practicable, correct correspondence with the inputs,

e. The absence of the recording system and/or the acquisition equipment.

2-1.5 RECORDER OPERATION

The flight recording systems shall start to record prior to the aircraft moving under its own power and record continuously, in accordance with the requirements of this MOPS, until the termination of the flight when the aircraft is no longer capable of moving under its own power. In addition, depending on the availability of electrical power, the recording system should start to record as early as possible during the cockpit checks prior to engine start at the beginning of the flight until the cockpit checks immediately following engine shutdown at the end of the flight.

2-1.6 BIT ERROR RATE

The bit error rate arising from differences between the input and the retrieved data caused by corruption of the data during processing, recording and retrieval shall not exceed one error in 10^5 bits.

2-1.7 SOFTWARE MANAGEMENT

Where equipment uses digital computer techniques the software practices shall follow the applicable guidelines specified in document EUROCAE ED-12B / RTCA DO-178B or subsequent issue. Software for recording functions shall be shown to comply with the guidelines applicable to at least Level E.

2-1.8 EQUIPMENT DESIGN SPECIFICATIONS

The design specifications for each recording system type are detailed in Parts I to IV.

2-1.9 RECORDING SYSTEMS SYNCHRONISATION

Correlation between onboard flight recording systems is recommended.

NOTE: *As far as reasonably practicable, all airborne recordings should be related to a single time reference such as GPS time. This helps establish an absolute time reference for recordings or partially recovered recordings.*

2-1.10 TIME BASE STABILITY

A stable time base or reference signal shall be used having an average accuracy of at least 0.1% (1000 ppm) obtained during information retrieval.

The recorded time base shall be reproducible with an accuracy of 0.1% (1000 ppm), averaged over a period of at least 1 minute.

2-1.11 MEANS OF HEAT DAMAGE ASSESSMENT FOR THE RECORDING MEDIUM

Where the recording medium cannot be readily and reliably inspected, means shall be provided to enable the accident investigator to determine, prior to an attempted replay, if the recording medium has been subjected to an excessive level of heat where the survival of the medium may be in doubt.

2-1.12 RETENTION OF RECORDED INFORMATION

Following the removal of electrical power to the recorder, the recording medium shall be capable of retaining the information recorded during the preceding operating time for a period of at least 2 years.

2-1.13 DIGITAL RECORDING AND RETRIEVAL CHARACTERISTICS

The organisation of the recording medium and the recording shall be such that:

a For an undamaged, fully serviceable memory with a normal recording, the recorded information is readily retrievable.

b For an undamaged, fully serviceable recording medium with a corrupted record, the information can be retrieved, using special techniques if needed, for the periods ending one second, maximum, prior to the period of corruption, and commencing one second, maximum, after the period of corruption.

c For a damaged or partially failed memory, the available information can be retrieved using special techniques, as required.

d The organisation of the memory shall contain provisions to detect corruptions in the recording or retrieval, or data losses due to medium management. These provisions could include time stamps, sequence numbers, and block checksums.

The manufacturers shall make available to the accident investigation community the detailed information and/or tools required to enable data recovery down to memory chip level (or equivalent).

2-1.14 CRASH SURVIVAL

2-1.14.1 Information Retrieval

The recording system shall be constructed such that the information in the recording medium can be retrieved using specified techniques as defined by the manufacturer.

2-1.14.2 Survival Criteria (Fixed Recording Systems)

a The robust memory module or the robust recorder shall be capable of preserving the recorded information when subjected to the following sequence of tests:

Impact shock followed by static crush then high temperature fire.

b The same test article shall be used for all of the tests required by the sequence.

c The need for repairs to the recording medium as a consequence of the crash survival tests shall be minimised. At the conclusion of the test sequence, it shall be possible to recover the data from the recording medium with only simple repairs such as replacing the interconnection harness to the robust memory module. Re-soldering memory devices or ancillary components is not considered a simple repair.

d Test procedures are defined in Chapter 2-4.

2-1.14.3 Survival Criteria (Deployable Recorders)

a The robust memory module or the robust recorder shall be capable of preserving the recorded information when subjected to the following sequences of tests.

Sequence 1: Impact shock followed by beacon transmission, then seaworthiness.

Sequence 2: Impact shock followed by high temperature fire.

b The same test article shall be used for all of the tests required by a sequence. It is not required for one test article to be subjected to both sequences.

c The need for repairs to the recording medium as a consequence of the crash survival tests shall be minimised. At the conclusion of a test sequence, it shall be possible to recover the data from the recording medium with only simple repairs such as replacing the interconnection harness to the robust memory module. Re-soldering memory devices or ancillary components is not considered a simple repair.

d Test procedures are defined in Chapter 2-4.

2-1.14.4 Identification

A high proportion of the area of the outer surfaces of the robust memory module shall be coloured bright orange. The outer surfaces of the robust memory module shall be inscribed with the following black letters as large as practicable: “FLIGHT RECORDER”.

The identification requirements shall be met after the robust memory module has been subjected to the tests, with the exception of the fire tests, specified in Chapter 2-4 or Chapter 2-4, as applicable.

CHAPTER 2-2

MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD TEST CONDITIONS (FIXED RECORDING SYSTEMS)

2-2.1 INTRODUCTION

The requirements for minimum performance under standard test conditions are flight recording system specific and are detailed in Chapter 3 of each of the relevant function specific Parts of this MOPS.

CHAPTER 2-3

MINIMUMPERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS (FIXED RECORDING SYSTEMS)

2-3.1 INTRODUCTION

This chapter specifies environmental test conditions. The equipment shall be tested as defined in EUROCAE ED-14F/RTCA DO-160F "Environmental Conditions and Test Procedures for Airborne Equipment", or subsequent issue, using the categories most applicable to the aircraft type, and the location of the equipment to be installed. The final choice of test classes within each environmental category will be defined by the equipment manufacturer. The objective of this level of testing is to prove that the equipment does not present a hazard to the aircraft, and can survive and continue to operate under the environmental conditions to which it will be subjected throughout its life.

Specific testing may be required to demonstrate that the equipment performs its intended functions when operated over the full environmental conditions to which it has been declared to comply, and throughout the extremes which it may be subjected to during an incident or accident. These tests can be undertaken during the specified ED-14F/RTCA DO-160F tests, or separately.

For the purposes of these environmental tests, the term 'equipment' shall be interpreted to include the recording equipment together with its accessories such as shock or anti-vibration mounts, where these are included as part of the installation for that particular aircraft type and equipment location.

Analysis may be substituted for a test where its use can be shown to produce equivalent evidence of compliance.

NOTE: Additional tests applicable to robustness of the recording medium are required for this specific equipment, as it is necessary for data to be recoverable following incidents and accidents well outside the standard environmental conditions defined in ED-14F/RTCA DO-160F. The extent of such tests is stated in Chapter 2-4.

CHAPTER 2-4

TEST PROCEDURES FOR CRASH SURVIVAL (FIXED RECORDING SYSTEMS)

2-4.1 GENERAL

This section specifies crash survival tests to be applied to the fixed robust recorder or the robust memory module to demonstrate compliance with paragraph 2-1.14.2.

a Prior to commencement of any crash survival testing a known, random digital data test pattern shall be recorded in the robust memory module.

b After the test sequence has been performed, this test pattern shall be readily recoverable to establish that the bit error rate defined in Chapter 2-4 has not been exceeded.

c On completion of a crash survival test sequence, the recording medium may be cleaned and dried. Alterations or repairs between tests shall not be made.

NOTE 1: *Microscopic examination of the surface characteristics of memory devices is not acceptable as means of data recovery.*

NOTE 2: *The repair of individual memory devices is not permitted.*

2-4.2 TEST PROCEDURES

2-4.2.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F, “Environmental Conditions and Test Procedures for Airborne Equipment”, paragraph 3.5 as:

a Temperature :+15 to +35°C

b Relative Humidity : Not greater than 85%

c Ambient Pressure : 84 to 107 kPa

2-4.2.2 Impact Shock

Subject the test article to an impact shock applied in each direction successively along three mutually orthogonal axes of the test article. The energy content of the impact shock shall be equal to or greater than that provided by a half-sine wave shock of 5 +/- 1 millisecond duration and a peak acceleration of 9806 m/s^2 (1 000 g). An acceptable means of compliance is to generate a trapezoidal shock that has an energy content equivalent to that of a half-sine wave as specified above, as shown in Figure 2-4.1 . The shock impulse shall be measured using a calibrated accelerometer and associated instrumentation having a 3dB response over a range of at least 5 to 250 Hz. The following test procedures apply:

a The test article shall be mounted on the shock test machine in such a manner that it can be subject to shock impulses in each direction successively along the three mutually orthogonal axes of the test article.

b Apply a 1 000 g shock impulse of duration 5 (±1) ms, to the article test in a direction coincident with the first orthogonal axis.

c Reset the activation mechanism.

d Repeat step b and c above, applying the impulse shock in the remaining five directions.

2-4.2.3 Static Crush

a Subject the test article to a static crush force of 4.54 kN (1,000 lb) applied continuously for a period of 5 minutes. At least four points on the test article, irrespective of its shape, shall be tested including, where applicable, each of the main diagonals and each of the main faces.

b The minimum number of tests to be performed will depend on the shape of the test article. Where a spherical shaped design is used, at least four tests will be required. For a cuboid shaped design, a total of seven tests will be required e.g. 3 faces plus 4 diagonals.

c The static crush test may be performed using a hydraulic press and pressure gauge.

d The test article may be supported in the press by means of circular resilient pads with a diameter of 5 cm (2 in) and a thickness of 1.25 cm (0.5 in).

e The crush force shall be adjusted following any collapse to restore the required pressure for the full 5 minute period.

2-4.2.4 High Temperature Fire

a Subject the test article to a fire producing a minimum thermal flux of 158 kW/m^2 (50 000 Btu/ft^2/hour). The entire external surface area of the test article shall be exposed to the fire for a continuous period of at least 15 minutes.

The flame temperature should be 1 100°C nominal. The turbulence and local flame cooling due to the test article under test may cause the temperature to vary between 950°C and 1 100°C. However, the minimum thermal flux stated herein shall be maintained for the duration of the test and monitored by suitable instrumentation. Shielding is not permitted.

An acceptable method is to subject the test article to a fire test with flames generated by an arrangement of burners either gas or oil fired. A mix of air and propane gas is the preferred fuel since the mixture burns cleanly and is readily controllable. The mixture is adjusted to obtain a stable flame.

b At the start of the fire tests precondition the test article to a stable internal temperature equivalent to that reached after operation at ambient pressure and temperature of 25°C ±5°C. Electronic components external to the robust memory module may be removed.

***NOTE*:** *As per ED-14F/DO-160F section 2.1, the equipment is considered stabilised when the temperature of the largest internal mass of the equipment does not vary by more than 2°C per hour. When temperature measurement of the largest internal mass is not practical, the minimum time considered applicable for temperature stabilization shall be two hours.*

c Where the effectiveness of the fire protection material decreases during normal operation and/or storage of the recording system, precondition the protective material to simulate the effects of ageing e.g. by means of extended pressure and temperature cycles.

d A water calorimeter shall be used to calibrate the burner array before the fire test is performed. The calorimeter shall be of the dimension shown in Figure 2-4.2.

Where other burner calibration methods are used such as electronic radiometry, the method shall be validated against the calorimeter method.

e Figure 2-4.3 shows an example of a suitable test arrangement using propane gas burners. The calorimeter is supported on steel angle sections approximately 0.5 m (20 inches) above the ground. The water inlet and outlet pipes are passed through an insulating block wall. The purpose of the wall is to reflect heat onto the rear of the calorimeter (or recorder) and to prevent the water pipes from absorbing heat. The short section of pipes between the wall and the calorimeter should be well insulated.

f The number and capacity of burners, their positions and the gas pressure should be adjusted to ensure the required criteria of flame coverage, thermal flux and nominal flame temperature are met. It is important that the source of water for the calorimeter, and the source of fuel for the fire, can maintain the required flow rates for the full test period. The flame temperature should be monitored continuously by thermocouples placed approximately 25 mm (1 inch) from the surface of the robust memory module or recording system at the approximate centre of a minimum of three faces. Burner output should be set by adjusting the individual burner gas valves.

g The thermal flux (Q) is given by:

$$Q = \frac{dT \times F \times SH}{A \times C} \quad W/m^2$$

Where dT = temperature rise in cooling water (°C)

F = flow rate of cooling water (kg/s)

SH = specific heat of cooling water (4187 Joules/kg/°C)

A = surface area of calorimeter (sq. metre)

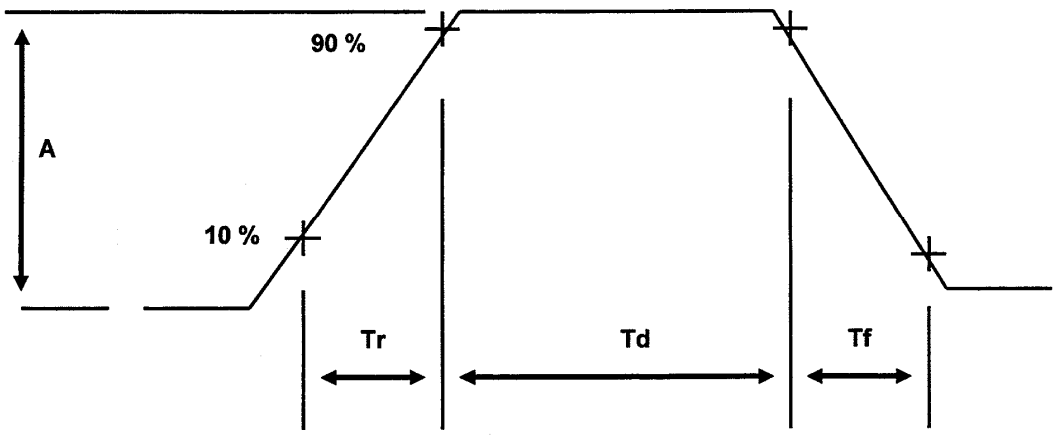
C = Absorption Constant. (A value of 0.5 shall be used)

h Once the required test conditions have been established, the gas pressure should be noted and the supply shut off at the main valve. The individual burner gas valves should not be touched.

i The test article shall be substituted for the calorimeter, by placing it at the centre of the fire. Where practicable, the internal temperature of the test article should be monitored in order to determine the margin of protection obtained for the particular recording medium. If construction is such that a significant portion of the robust memory module or recording system has been damaged as a result of previous tests and is likely to melt or burn away during the test, the robust memory module or recording system shall be supported in such a way that the robust memory module will be subjected to the full thermal flux for the duration of the test.

j The fire test is started by turning on the main gas valve. If necessary, this valve should be used to control the gas pressure to the level noted in step h above. Flame temperature, as indicated by the external thermocouples, shall be continuously monitored. A higher temperature than that achieved during the calorimeter test may be observed due to the presence of the robust memory module or recording system. The burner outputs shall not be altered to compensate for this difference.

k At the end of the test period, the burners should be shut off and the robust memory module or recording system be allowed to cool naturally in ambient conditions. It is permissible to remove the recording system from the vicinity of the support arrangement.



Tr = 3.0 ms maximum

Td = 2.2 ms minimum

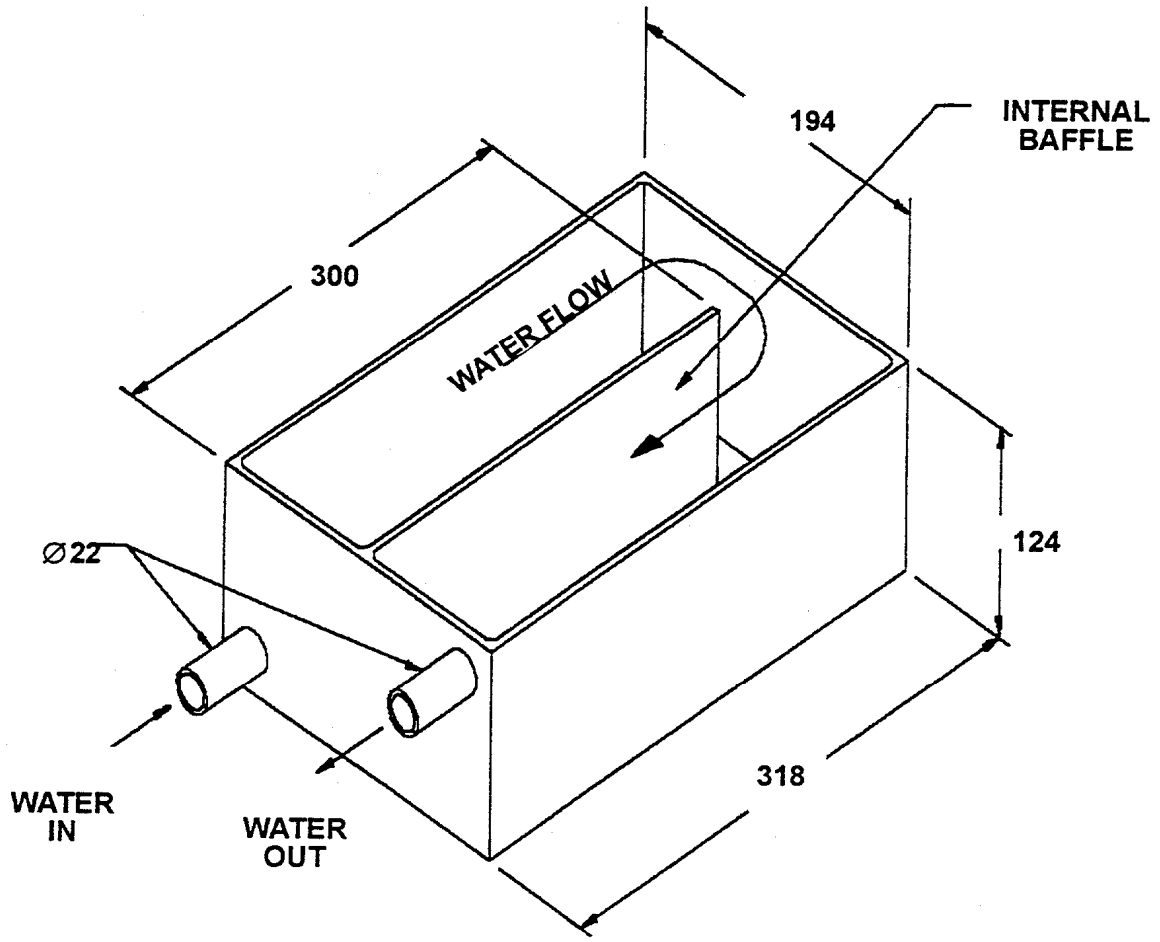
Tf = 0 ms minimum

A = 1 000 g (9806 m/s²) minimum

***NOTE 1*:** *The intervals Tr and Tf shall be such that the area under the curve is equal to or greater than that of a half-sine wave shock pulse i.e. Area = (5 x 10^{-3}) x 1000/(Pi/2) = 3.183 g-seconds*

***NOTE 2*:** *In practice, significant ringing of the shock pulse will be observed. Averaging may be applied to establish the effective pulse shape.*

FIGURE 2-4.1: TRAPEZOIDAL IMPACT SHOCK WAVEFORM



NOTES:

a. top removed for clarity

b. material is 1.6 mm mild steel

c. dimensions in millimetres

FIGURE 2-4.2: EXAMPLE OF SUITABLE WATER CALORIMETER

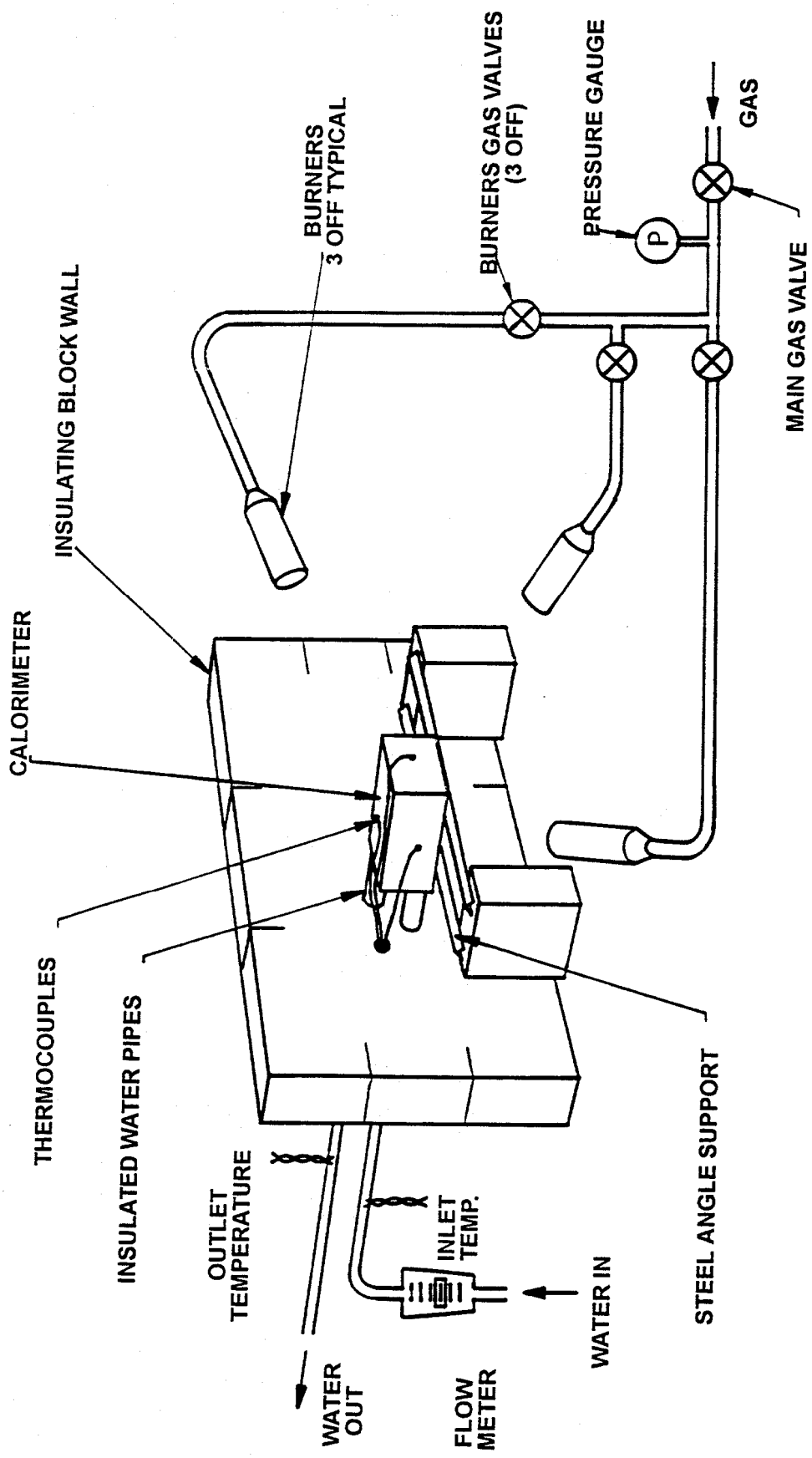


FIGURE 2-4.3: EXAMPLE OF SUITABLE FIRE TEST APPARATUS

CHAPTER 2-5

EQUIPMENT INSTALLATION AND INSTALLED PERFORMANCE

2-5.1 INTRODUCTION

This chapter specifies installation characteristics and performance with procedures for verifying that performance when the equipment is installed in an aircraft.

Installed performance criteria are generally the same as those contained in this section, which were verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be confirmed after installation.

2-5.2 GENERAL

Equipment shall be compatible with the environmental conditions present in the specific location in the aircraft where the equipment is installed.

Where the system is connected to mandatory instruments or data sources used for controlling or indicating the flight path of the aircraft, adequate isolation between the instruments or data sources and the flight recording system shall be provided. Particular attention shall be given to ensuring that the segregation required between critical components or systems of the aircraft e.g. power plant installation segregation, is not violated by the installation of the flight recording system.

2-5.3 EQUIPMENT INSTALLATION

2-5.3.1 Aircraft Environment

The flight recording system shall be installed so that it operates within the environmental conditions to which the items of equipment comprising the system have been declared to comply. Operation of the recording system shall not be affected by aircraft manoeuvring or changes in attitude encountered within the certified operational envelope of the aircraft. Operation of the recording system should not be affected by those extreme conditions likely to be encountered during an accident sequence e.g., violent and extreme manoeuvres.

2-5.3.2 Failure Protection

Any probable failure of the flight recording system shall not degrade the airworthiness of the aircraft.

2-5.3.3 Interference Effects

The installed recording system shall not:

a be the source of harmful conducted or radiated interference, nor

b be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

NOTE: *Electromagnetic compatibility problems noted after installation of the equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installer will be responsible for resolving any incompatibility between the equipment and previously installed equipment.*

2-5.3.4 Stray Magnetic Field

When the recording system is placed, either in an operating or non-operating state in an area free from local magnetic disturbances, the stray magnetic field of this equipment shall cause not more than a 1 degree deflection of a magnetic compass when the closest edge of the equipment is at a distance of 300 mm from the compass.

2-5.3.5 Insulation Resistance

The insulation resistance between any exposed conducting material of the recording system (non-electrical circuit) and the electrical circuit of this equipment shall be at least 10 MOhms when measured with an applied voltage of at least 50 volts DC.

2-5.3.6 Inadvertent Turnoff

Protection shall be provided, or the installation shall be designed, to prevent the inadvertent turnoff of the recording system.

2-5.3.7 Aircraft Electrical Power Source

The recording system shall be connected to a power source having the characteristics which ensure proper and reliable recording in the operational environment.

2-5.4 EQUIPMENT LOCATION

2-5.4.1 Location of Robust Recorder

Insofar as it is practicable, each robust recorder should be located and mounted so as to minimise the probability of container rupture resulting from crash impact. Also the risk of exposure of the recording medium to subsequent damage from fire should be minimised.

2-5.5 INSTALLATION OF EQUIPMENT

2-5.5.1 Strength of Installation

The structural provisions within the aircraft for the mounting of the robust recorder (including its anti-vibration mount where used) should be able to withstand the loads (to be treated as limit loads) resulting from severe vibration or buffet. In addition, the strength of the local attachments shall be able to withstand the crash safety loads prescribed for the aircraft.

SECTION 3

DEPLOYABLE RECORDERS

CHAPTER 3-1

GENERAL

3-1.1 INTRODUCTION

This section details the additional requirements and exceptions that are specific to lightweight deployable recorders. The requirements specified in this section shall be met in addition to the requirements of Section 1 and Section 2, Chapter 2-1 and the appropriate recording system specific parts. It is applicable to any robust recorder that is designed to be deployed, its ancillary equipment and its installation in civil aircraft.

3-1.2 DEPLOYABLE RECORDING SYSTEM TECHNOLOGY

A deployable recorder is a recording medium housed in an enclosure that is automatically deployed (released) from the aircraft at the start of an accident sequence. Its characteristics have the objective of enabling it to land at lower speeds clear of the main aircraft wreckage, or, in the event of an accident over water, its flotation characteristics enable it to float. Since the recorder is no longer with the aircraft it should be equipped with a means to locate it.

This type of recorder is attached to the exterior of the airframe, and under normal conditions, functions in the same manner as a fixed recorder. The recorder memory module, beacon transmitters, antennas, battery pack and the survival packaging for these units are all an integral part of the automatic deployable package.

The deployable package incorporates flight characteristics that enable it to deploy and rapidly establish a flight trajectory that clears the airframe.

Compliance with this section will ensure that deployable systems will perform their function under the conditions encountered in aircraft operations.

3-1.3 AIRWORTHINESS AND CERTIFICATION

3-1.3.1 Safety

In addition to the safety requirements specified in paragraph 2-1.3.1, the exterior of the equipment shall have no sharp edges or projections that could damage inflatable survival equipment or injure persons.

3-1.3.2 Documents for Certification

In addition to the certification documents specified in paragraph 2-1.3.4, the following shall be provided.

a Instructions shall be provided for safely removing deployable recorders from the aircraft for maintenance purposes.

b The transmission frequency and modulation characteristics of the radio location beacon.

3-1.4 RECORDER OPERATION

In addition to the requirements defined in paragraph 2-1.5, the deployable recorder shall not continue to record once it has been deployed.

3-1.5 DEPLOYMENT CRITERIA

a The design characteristics of a deployable recorder shall result in the recorder landing clear of the aircraft wreckage.

b The unit shall incorporate flight characteristics that enable it to rapidly establish a flight trajectory that clears the airframe.

c The unit shall not be given sufficient initial momentum on deployment such that its release could endanger ground support personnel or the aircraft itself.

d Sufficient sensors shall be installed and located to detect impact, and water immersion resulting from an accident.

e Controls and safeguards shall be in place to prevent inadvertent manual deployment.

3-1.5.1 Impact Initiation

a There shall be an automatic means of impact detection and deployment initiation. Frangible or deformation sensors shall be installed in both the nose and the tail of the aircraft.

b An alternative solution is installation of single or multiple MEMS based G-switches or accelerometers with deploy algorithms based on industry best practices in crash detection.

c Impact sensors shall be designed such that they will only trigger when the structure has been significantly deformed (representing a catastrophic accident).

3-1.5.2 Hydrostatic Initiation

For both fixed and rotary wing aircraft, a hydrostatic sensor shall deploy the recorder at a depth of 3m or more.

3-1.6 CRASH SURVIVAL

3-1.6.1 Deployable recorder

Paragraph 2-1.3.4 defines the crash survival tests to be performed on the deployable recorder system.

3-1.6.2 Radio Location Beacon

All deployable recorders shall be equipped with a radio location beacon compliant with the requirements of ED-62 or RTCA DO-204A. This beacon shall be part of the deployable package.

The radio locating device shall be attached to the deployable recorder such that the aerodynamic properties of the recorder are not adversely affected and the risk of damage to, or separation of, the locating device is minimised.

In addition to meeting the endurance requirements of ED-62 (50 hours), the 121.5 MHz homing frequency of the ELT shall operate for a minimum of 100 additional hours, bringing the total minimum operational duration to 150 hours. For the additional 100 hours duration the ELT is not required to operate at the same power as the initial 50 hours but it shall have a minimum EIRP of 5mW.

NOTE: *Other required characteristics of the radio location beacon are outside the scope of this MOPS. Reference should be made to the applicable equipment standard.*

CHAPTER 3-2

MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD TEST CONDITIONS

3-2.1 INTRODUCTION

The requirements for minimum performance under standard test conditions are flight recording system specific and are detailed in Chapter 3 of each of the relevant function specific Parts of this MOPS.

CHAPTER 3-3

MINIMUM PERFORMANCE UNDER ENVIRONMENTAL TEST CONDITIONS

3-3.1 INTRODUCTION

Chapter 2-3 defines the environmental tests to be performed on the recorder system.

Deployable recorders shall satisfy the functional requirements as detailed in Chapter 4 of each of the applicable function specific Part(s).

CHAPTER 3-4

TEST PROCEDURES FOR CRASH SURVIVAL

3-4.1 GENERAL

This chapter replaces the procedures for crash survival defined in Chapter 2-4.

This section specifies crash survival tests to be applied to the deployable robust recorder to demonstrate compliance with paragraph 2-1.14.3.

a Prior to commencement of any crash survival testing a known, random digital data test pattern shall be recorded in the robust memory medium.

b After the test sequences have been performed, this test pattern shall be readily recoverable and replayed to establish that the data error rate defined in 2-1.6 has not been exceeded.

c On completion of a crash survival test sequence, the recording medium may be cleaned and dried. Alterations or repairs between tests shall not be made.

NOTE 1: *Microscopic examination of the surface characteristics of memory devices is not acceptable as means of data recovery.*

***NOTE 2*:** *The repair of individual memory devices is not permitted.*

3-4.2 TEST PROCEDURES

3-4.2.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F, “Environmental Conditions and Test Procedures for Airborne Equipment”, paragraph 3.5 as:

a Temperature :+15 to +35°C

b Relative Humidity : Not greater than 85%

c Ambient Pressure : 84 to 107 kPa

3-4.2.2 Impact Shock

The integrity of the robust recording medium contents and the proper operation of the radio location beacon are to be validated when subjected to the following impact shock test.

a Subject the deployable recorder package, to an impact shock applied to the most probable landing attitude in the most damage vulnerable direction. The shock shall be such a level as to simulate a landing velocity of 25 m/s (80 ft/s) onto a hard surface such as rock, concrete or steel.

***NOTE*:** *The definitions of “landing attitude” and “most damage-vulnerable direction” should not be limited to the three primary axes of the recorder.*

b The deployable recorder containing the robust memory module shall impact or be impacted by a hard surface (50 mm thick steel plate of dimensions greater that the overall dimensions of the recorder) at a minimum impact velocity of 25 m/s (80 ft/s). Figure 3-4.1 illustrates an acceptable impact shock test setup for deployable recorders. Figure 3-4.2 illustrates an acceptable method and setup for retrieval of the deployable after impact. The mass of the impact plate shall be greater than 10 times the mass of the deployable recorder and experience no yield when subjected to the impact.

3-4.2.3 Radio Location Beacon Transmission

Place the deployable recorder in a shielded bag and confirm that the beacon transmits on 121.5 MHz with required power output for at least 150 hours.

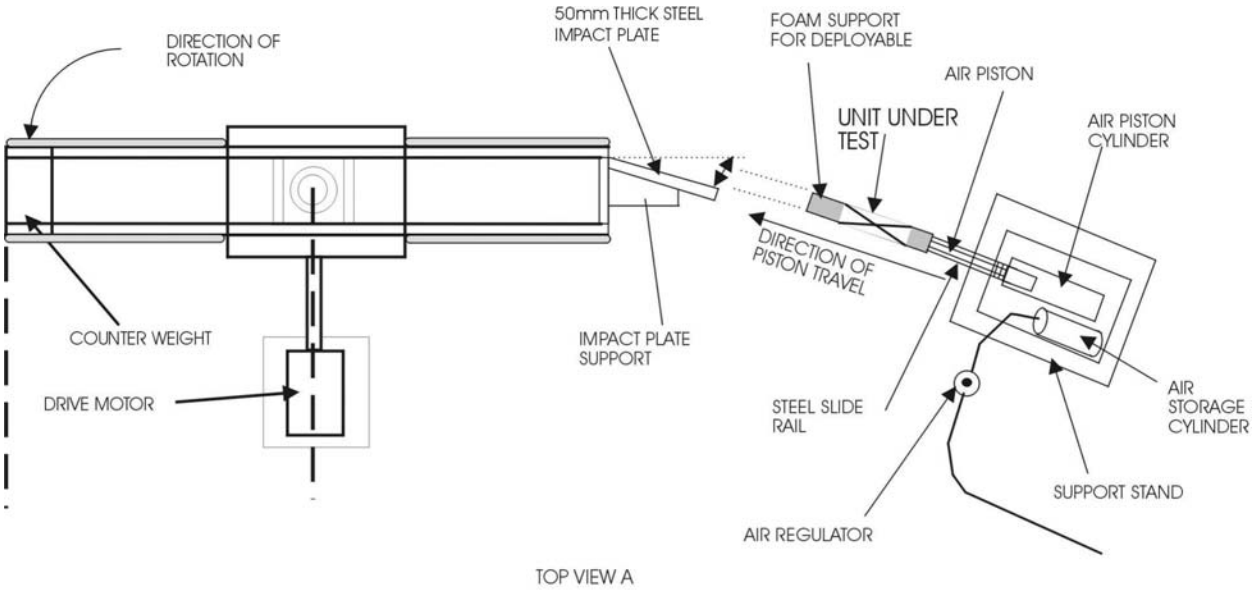
3-4.2.4 Seaworthiness

The deployable package shall be buoyant and sufficiently self-righting in fresh and salt water to maintain the antenna substantially in its normal operating position. This shall be demonstrated by testing with fresh and then salt water and confirming the reception of 121.5 MHz transmissions from the transmitter. This test shall be performed in water conditions representative of an open sea state 7 (equivalent to Beaufort scale force 10).

3-4.2.5 High Temperature Fire

Subject the test article to a fire producing a minimum thermal flux of 158 kW/m^2 (50 000 Btu/ft^2/hour). The entire external surface area of the test article shall be exposed to the fire for a continuous period of at least 5 minutes.

The method of testing the test article is identical to the paragraph 2-4.2.4.



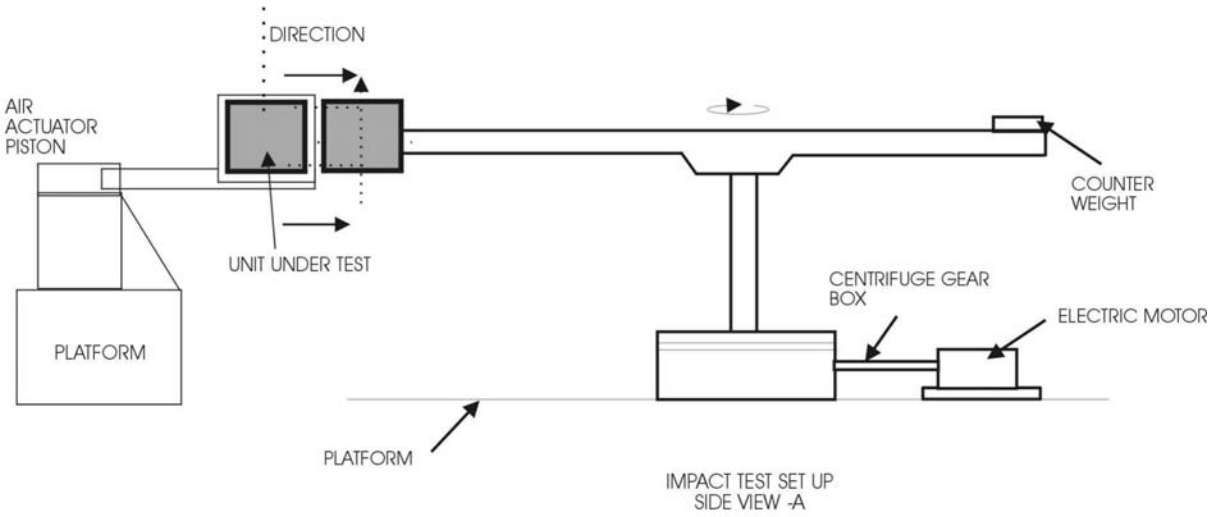


FIGURE 3-4.1: IMPACT SHOCK TEST SETUP

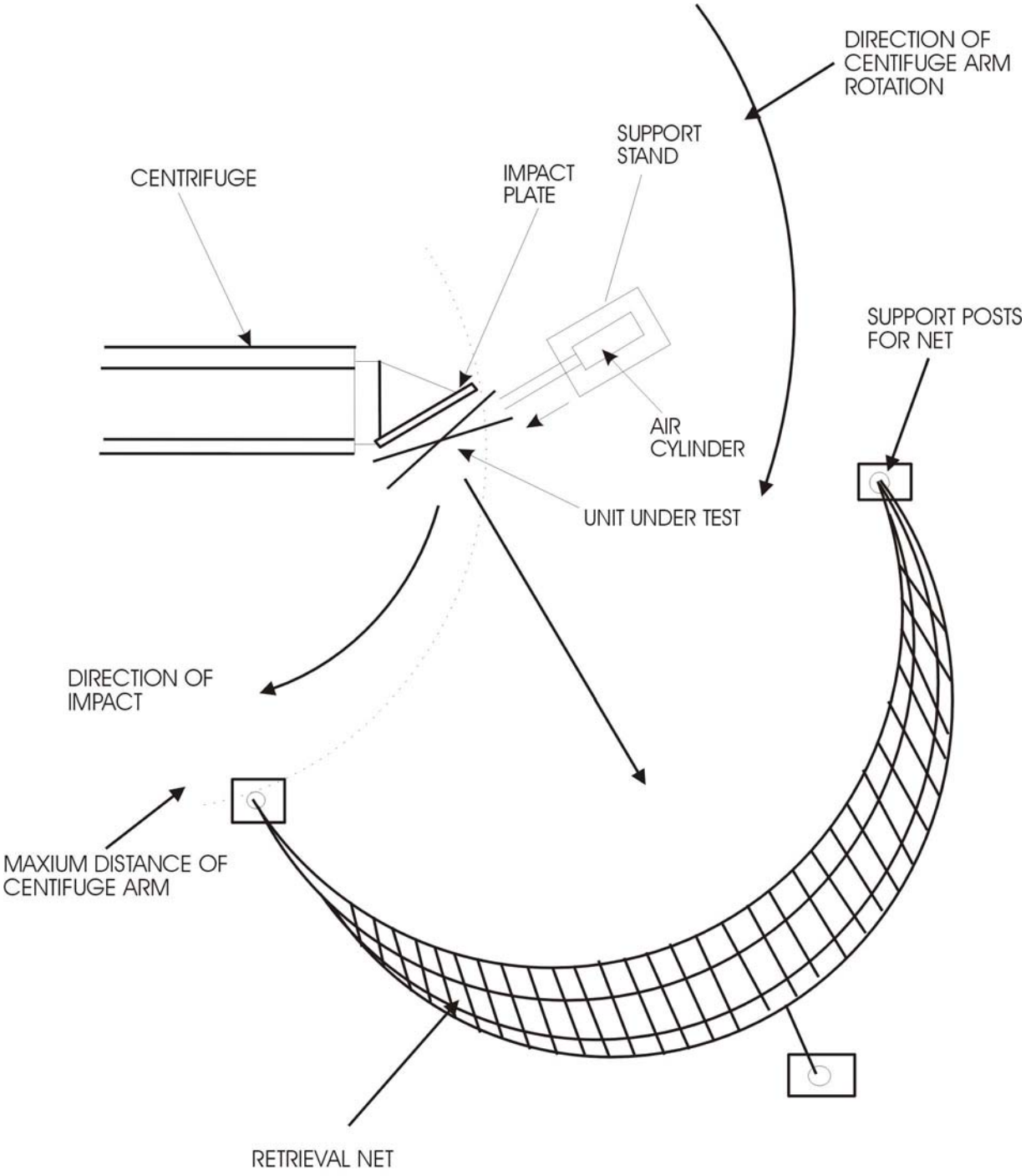


FIGURE 3-4.2: IMPACT TEST RETRIEVAL MECHANISM

CHAPTER 3-5

EQUIPMENT INSTALLATION AND INSTALLED PERFORMANCE

3-5.1 INTRODUCTION

This chapter specifies installation characteristics and performance with procedures for verifying that performance when the equipment is installed in an aircraft.

Installed performance criteria are generally the same as those contained in this section, which were verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be confirmed after installation.

3-5.2 GENERAL

Equipment shall be compatible with the environmental conditions present in the specific location in the aircraft where the equipment is installed.

Where the system is connected to mandatory instruments or data sources used for controlling or indicating the flight path of the aircraft, adequate isolation between the instruments or data sources and the flight recording system shall be provided. Particular attention shall be given to ensuring that the segregation required between critical components or systems of the aircraft e.g. power plant installation segregation, is not violated by the installation of the flight recording system.

3-5.3 EQUIPMENT INSTALLATION

3-5.3.1 Aircraft Environment

The flight recording system shall be installed so that it operates within the environmental conditions to which the items of equipment comprising the system have been declared to comply. Operation of the recording system shall not be affected by aircraft manoeuvring or changes in attitude encountered within the certified operational envelope of the aircraft. Operation of the recording system should not be affected by those extreme conditions likely to be encountered during an accident sequence e.g., violent and extreme manoeuvres.

3-5.3.2 Failure Protection

Any probable failure of the flight recording system shall not degrade the airworthiness of the aircraft.

3-5.3.3 Interference Effects

The installed recording system shall not:

a be the source of harmful conducted or radiated interference, nor

b be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

NOTE: *Electromagnetic compatibility problems noted after installation of the equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installer will be responsible for resolving any incompatibility between the equipment and previously installed equipment.*

3-5.3.4 Stray Magnetic Field

When the recording system is placed, either in an operating or non-operating state in an area free from local magnetic disturbances, the stray magnetic field of this equipment shall cause not more than a 1 degree deflection of a magnetic compass when the closest edge of the equipment is at a distance of 300 mm from the compass.

3-5.3.5 Insulation Resistance

The insulation resistance between any exposed conducting material of the recording system (non-electrical circuit) and the electrical circuit of this equipment shall be at least 10 MOhms when measured with an applied voltage of at least 50 volts DC.

3-5.3.6 Inadvertent Turnoff

Protection shall be provided, or the installation shall be designed, to prevent the inadvertent turnoff of the recording system.

3-5.3.7 Aircraft Electrical Power Source

In addition to the requirements of paragraph 2-5.3.7, the electrical supply for the deployment mechanism shall be from a source which provides maximum integrity for system operation under crash conditions including sinking. An independent battery, located immediately adjacent to the deployment mechanism, shall be provided for activation of the mechanism.

3-5.4 EQUIPMENT LOCATION

3-5.4.1 Location of robust recorder

In addition to the requirements of paragraph 2-5.4.1, each deployable recorder shall be located and mounted so as to minimise hazards resulting from intended or inadvertent deployment of the recorder. The deployment trajectory shall not create a hazard to the aircraft in any flight condition.

The location of the deployable recorder on the airframe shall be established to ensure that the deployed recorder clears the airframe.

3-5.4.2 Fixed Wing Aircraft Installations

The following installation requirements shall be met when designing a deployable recorder installation for fixed wing aircraft:

a The deployable package including the recorder shall be mounted as far aft on the airframe as is practicable and where possible in a non-pressurised section of the fuselage. Other acceptable locations include the dorsal fin and tail cone. The installation may produce any combination of upward and sideways deployment. It is not acceptable for the recorder to be deployed downwards when the aircraft is in a normal range of flight attitudes.

b When the design of the airframe dictates that a pressurised structure is cut, the size of the opening shall be limited to the smallest practical size.

c The deployable package shall separate from the aircraft cleanly without striking any part of the airframe. Proper deployment shall be achieved for the whole flight envelope including a margin outside the normal flight envelope which might be expected during the initial stages of an accident sequence. Similarly, deployment from an aircraft in an unusual attitude should not make the survival of the recorder less likely. In selecting the location of the deployable package, consideration shall be given to antennas or other items protruding from the airframe. The airflow characteristics which may determine the flight path of the deployed recorder shall be analysed.

d Crash sensors shall be installed and located to detect the earliest indication of a accident sequence in order to provide the highest assurance of survival for the deployable package. The positioning of the sensors should take the shape of the aircraft into account (refer to paragraph 3-1.5.1).

e Crash sensors shall be designed to minimise the risk of inadvertent deployment.

f Hydrostatic deployment shall be demonstrated.

3-5.4.3 Helicopter Installations

The following installation requirements shall be met when designing a deployable recorder installation for helicopters:

a The selected location shall provide a deployment trajectory which is clear of the airframe and of the rotors when deployed at any point in the flight envelope. It is not acceptable for the recorder to be deployed downwards when the helicopter is in a normal range of flight attitudes.

b Crash sensors shall be installed and located to detect the earliest indication of a accident sequence in order to provide the highest assurance of survival for the deployable package. The positioning of the sensors should take the shape of the helicopter into account (refer to paragraph 3-1.5.1).

c Crash sensors shall be designed to minimise the risk of inadvertent deployment.

d Hydrostatic deployment shall be demonstrated.

PART I

COCKPIT AUDIO RECORDING SYSTEMS

CHAPTER I-1

INTRODUCTION

I-1.1 PURPOSE AND SCOPE

I-1.1.1 General

This part defines the minimum specification to be met for a Cockpit Audio Recording System. This part shall be read in conjunction with Sections 1 and 2, together with Section 3 if applicable.

I-1.1.2 Description of Content

This part is divided into six Chapters and two Annexes.

Chapter I-1 describes typical equipment applications and operational objectives. Background material and accident investigation considerations are included together with a description of the CARS.

Chapter I-2 defines the general design specification.

Chapter I-3 defines the minimum system performance under standard test conditions.

Chapter I-4 defines the minimum system performance under environmental test conditions.

Chapter I-5 specifies tests and procedures for determining compliance with the performance requirements.

Chapter I-6 defines the installed equipment performance requirements including ground tests and flight tests.

The Annexes give additional guidance on replay, recording evaluation and maintenance practices.

I-1.2 APPLICATION

I-1.2.1 Cockpit Audio Recording System

Compliance with this Part will ensure that the CARS will perform its intended function under the conditions encountered in aircraft operations.

I-1.3 DESCRIPTION OF THE SYSTEM

I-1.3.1 Equipment

The CARS may include the following equipments as appropriate to the aircraft:

a Cockpit equipment, including controls for bulk erase functions, failure indication and an area microphone with associated preamplifier,

b A robust recorder in which it is recommended that the recording be synchronised with the other airborne recording systems and UTC,

c A means of converting the analogue audio signals to a digital format,

d Audio interface equipment, including signal summing amplifiers.

I-1.3.2 Operational Considerations

a Objectives

Each CARS should be installed so as to provide with reference to a timescale, simultaneous recordings, on separate channels, of:

i. area microphone – the aural environment of the cockpit,

ii. pilot's audio – pilot's headset audio, which may include:

Pilot's voice communications,

radio communications,

audio signals identifying navigation or approach aids,

warnings and alerts introduced into the headsets,

public address announcements made by the pilots.

***NOTE*:** *Where possible there is significant benefit to recording individual pilots, using hot microphones, on separate pilot audio channels.*

b Start and Termination of Recording

Recorder operation shall be as defined in paragraph 2-1.5.

CHAPTER I-2

CARS DESIGN SPECIFICATION

I-2.1 EQUIPMENT DESIGN SPECIFICATION

I-2.1.1 General

This chapter is applicable to the functions of a flight recording system designed to receive, process, record and preserve audio information in accordance with the requirements of this MOPS. These functions shall be performed reliably even under adverse operating conditions including events leading to an accident.

This section shall be read in conjunction with Section 2, which defines the requirements that are generic to all flight recording systems.

I-2.1.2 Recording Techniques

a The CARS shall use a digital method of recording and storing the data in a robust memory module.

b The area microphone audio information shall be converted to digital format. This shall be stored in an unencrypted, uncompressed linear (no μ-law or a-law) PCM, 16 bit, 44.1 kHz.

NOTE: *In addition to speech the area microphone recording will contain non speech audio information including turbine frequencies, gearbox signatures, aerodynamic and mechanical sounds which are invaluable to accident investigators. To ensure these non speech sounds are accurately recorded, codecs which employ psycho-acoustic (e.g. mp3) or predictive (e.g. CELP) methods must not be used.*

c The pilot's audio channel(s) audio information shall be converted to digital format. This shall be stored in an unencrypted, uncompressed linear (no μ-law or a-law) PCM, 16 bit, 11.025 kHz, 22.050 kHz or 44.1 kHz.

d Silence editing shall not be used.

NOTE 1: *It is acceptable to use the LSB of the 16 bits to encode a serial time stamp.*

NOTE 2: *The specific format of the storage method has been stipulated to overcome industry problems with some of the current methods of recording audio whereby details of proprietary audio codecs have been lost over time.*

NOTE 3: *The requirement to use uncompressed audio improves the recovery strategy with regards to partial file recovery and removes the need for complicated audio quality standards checks such as Speech Transmission Index (STI).*

NOTE 4: *Simplicity of design suggests that the voice channel is sampled at the same rate as the area microphone. One objective of this standard is to maximize usefulness of the recordings to the owner. To this end, maintaining the same file format for both the area microphone and voice channel simplifies the replay for the end user.*

NOTE 4: *Physical memory segregation of the audio channels is not required.*

I-2.1.3 Recording Capacity

The CARS shall be capable of retaining the data recorded during at least the last 2 hours of its operation. The recording of information as separate channels shall be maintained for the entire duration of the recording.

I-2.1.4 Means of Access to Recorded Information

The means for accessing the recorded information shall:

a Not erase, re-write or alter the recording,

b use a standard computer interface and file format (.wav file for example) for lossless retrieval of all non-erased audio,

c use a method of audio transfer of erased data that requires removal of the unit to a workshop and supports the concept of only accident investigation authorities having access to this erased data,

d not require a special key, code, that would otherwise hamper an accident investigation authority's access to the recordings.

NOTE: *It is not required for the CARS to continue to record audio information whilst the recorded data is retrieved.*

I-2.1.5 Recording Delay and Synchronisation

a Recording Delay: Audio Signals

The delay in recording the audio signals from the time of reception at the area microphone to the time of recording in the robust memory module shall not exceed 50 milliseconds.

For the other channel(s), the delay in recording the audio signals from the time of reception at the recorder input to the time of recording in the robust memory module shall not exceed 50 milliseconds.

NOTE: *The installer should minimize the delay in presenting the pilot channel(s) to the CARS.*

b Channel Synchronisation: Audio Signals

The recordings for separate channels shall be made such that, when replayed, the relative time between channels shall not exceed 4 milliseconds over the recording period.

***NOTE*:** *The sample triggers for each channel should be derived from the same timing source to ensure the recordings stay synchronised.*

I-2.1.6 Bulk Erase

a Provision should be made for a pilot-operated, post-flight bulk erase function.

b After use of a bulk erase function, the recording shall be modified so that it cannot be retrieved using any and all normal replay or copying techniques.

c The installation of a bulk erase function should be designed to prevent activation during flight and to minimize any inadvertent operation during a crash impact.

NOTE 1: *An acceptable means of compliance would be for a bulk erase function to alter only the specific information needed to access or copy the memory using normal replay procedures. The actual data stored in memory need not be deleted or altered.*

NOTE 2: *Normal replay is audio or audio data retrieval from the system by the pilots and operator to support flight review, by the maintainer to support installation maintenance or by the aircraft constructors and modifiers to support certification of recorder installations.*

NOTE 3: *In the event of bulk erasure, non-normal replay or copying techniques may be used by the accident investigation authority to retrieve data, if available, for the purposes of conducting an official investigation.*

NOTE 4: *Non-normal replay is data retrieval from the memory module using special techniques available to the recorder manufacturers and accident investigation authorities for dealing with severely damaged recorders.*

NOTE 5: *Military organisations may use commercial recorders and have different bulk erase requirements.*

I-2.1.7 Quality and Reliability of Recording

a For each new CARS installation type, the performance of the system and quality of recording shall be established by analysis of audio recorded on the ground and in flight (Annex I-A).

b It is recommended that the relevant accident investigation authority should be invited by the certification authority to participate in the assessment of new systems and the quality of the recorded audio (I-A.1.6).

I-2.1.8 Digital Systems Characteristics

In digital systems, overdrive conditions can result in severe distortion if not properly handled. It is desirable to have the digital system handle an overdrive condition in the same way as an analogue system does.

The design of a digital system's input stage should limit the maximum and minimum values of the digital word used to represent the input. This ensures that the system response to an input overdrive condition will be in the form of a predictable clipping at the system output. An output overdrive condition can result when multiple inputs are improperly combined.

In digital audio systems, output stage overdrives normally occur in the digital signal processor. A processor will need to be able to handle an overdrive condition in the same way as an analogue system. Operation of a digital signal processor in its overflow or saturation mode would require that any overflow shall set a value at its largest positive or negative value depending on the direction of the overflow. This prevents errors due to wraparound and yields properly limited inputs and outputs.

CHAPTER I-3

MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD TEST CONDITIONS

I-3.1 INTRODUCTION

This chapter provides the minimum performance specification of the equipment and the levels to be demonstrated under standard test conditions.

I-3.1.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F, "Environmental Conditions and Test Procedures for Airborne Equipment", paragraph 3.5 as:

a Temperature : +15 to +35°C

b Relative Humidity : Not greater than 85%

c Ambient Pressure : 84 to 107 kPa

In addition to the above, the electrical power supply shall be within the limits specified as Normal in Section 16 of ED-14F/DO-160F or subsequent issue.

In the case of equipment designed for operation from an AC power source of variable frequency, unless otherwise specified, tests should be performed at representative input power frequencies with the input frequency adjusted to within 5% of a selected frequency.

In the tests that follow, unless otherwise stated, the Reference Signal is defined as a 1 kHz sine wave having an amplitude equal to the maximum level for which the equipment is designed.

I-3.2 RECORDING SYSTEM MINIMUM PERFORMANCE LEVELS

The recording system shall be tested to show compliance with the following minimum performance levels.

***NOTE*:** *Where these paragraphs state requirements regarding the information in the recording medium it should be interpreted as that obtained by numerical analysis of the recorded audio data or as that observed at the output of suitable playback equipment.*

I-3.2.1 Start-up and Effects of Power Interruptions

Following a system electrical power interruption, the characteristics of the CARS (including any networks, busses etc) shall be such that:

a Following initial application of power to the CARS and any start logic is satisfied, or following an interruption with a duration of more than two seconds, the recording system shall commence and continue to store information, in accordance with the requirements of this MOPS, within 5 seconds, and any built in test function shall be completed within 60 seconds.

b All information available at the start of an interruption together with that available in the following 2 seconds shall be recorded in the robust memory module.

c After 5 seconds at a normal power level, interruptions with duration of up to 2 seconds shall have no effect on the CARS, area microphone and CARS control panel (including any interconnecting networks, busses etc). The initial 5 second period allows time to recharge the energy storage.

I-3.2.2 Signal Level – Balance Between Audio Channels

If more than one pilot audio channel is provided then, when half the Reference Signal Level is applied to the channels, the maximum difference between the signals recovered from each pilot channel shall be less than 3 dB.

If more than one CAM channel is provided then, when half the Reference Signal Level is applied to the channels, the maximum difference between the signals recovered from each CAM channel shall be less than 3 dB.

I-3.2.3 Audio Frequency Response

a When half the Reference Signal level is applied to the input of the area microphone channel and its frequency is swept continuously at a rate not exceeding 0.1 octaves per second over the range defined in Table I-3.1. The level of the signal recovered from the memory shall not vary by more than a total range of +/- 3 dB.

b In respect of the pilot audio channels, the above requirement shall be met for a signal frequency range of at least 150 Hz to 5 kHz. For frequencies below 150 Hz, all pilots audio channels shall attenuate the signals at a nominal 12 dB per octave. A second order high-pass filter characteristic shall be used.

c In respect of the area microphone channel, the above requirement shall be met for a signal frequency range of at least 150 Hz to 20 kHz. For frequencies below 150 Hz, area microphone channel shall attenuate the signals at a nominal 12 dB per octave. A second order high-pass filter characteristic shall be used.

***NOTE*:** *There is a significant value to the mechanical signatures that would be found below 150 Hz. However, there is also the potential for significant audio energy in this region which could saturate the recording. Therefore, it is desirable to have a second order roll off of the frequency response below 150 Hz rather than a step attenuation.*

I-3.2.4 Audio Noise Level – Signal to Noise

With no signal applied to any input channel, the reproduced signal shall be below the output level produced by an input Reference Signal by the value defined in Table I-3.1.

This requirement shall be met across the frequency band as defined in Table I-3.1 with the input both open and short circuited. The above Signal to Noise performance shall be met in the presence of out-of-band input signals at the Reference level when tested in accordance with paragraph I-5.2.3.

NOTE: *If audio channels are specified with the audio frequency response of the area channel, the area channel out-of-band signal definition shall apply.*

I-3.2.5 Audio Noise Level – Total Harmonic Distortion plus Noise (THD+N)

The reproduced total harmonic distortion plus noise shall not exceed the value defined in Table I-3.1 when measured in the stated frequency band at input levels of 0 to -20 dB relative to the stated channel signal level.

NOTE: *Overdrive considerations are discussed in paragraph I-2.1.8.*

I-3.2.6 Cross-talk between Audio Channels

When the Reference Signal is applied to any one of the inputs of the required audio recording channel, the level of the signal, recorded on that part of the memory assigned to each of the other recording channels, shall be below the level recorded on the intended channel by at least the amount defined in Table I-3.1.

I-3.3 AREA MICROPHONE AND PREAMPLIFIER

The microphone sensitivity and output impedance are not controlled by this document. These values should be chosen for compatibility with the microphone preamplifier and the combination specified together as a complete unit.

NOTE: *The use of separate specifications for the area microphone and preamplifier does not preclude combining any or all of the functions in a single unit.*

I-3.3.1 Frequency Response – Area Microphone

The output level of the microphone shall comply with the frequency response requirements listed in Table I-3.1. This requirement shall be met over a sound pressure input range of 60 dB to 94 dB above 20 µPa.

I-3.3.2 Total Harmonic Distortion plus Noise – Area Microphone

The total harmonic distortion plus noise contributed by the microphone shall be less than 1% (-40dB) at sound pressure levels up to 120 dB above 20 µPa in a free field at 1 kHz when measured in a 22 kHz bandwidth (unweighted).

I-3.3.3 Polar Response – Area Microphone

The directivity or polar response pattern of the Cockpit Area Microphone is not specified by this MOPS.

NOTE*:* *The best microphone response pattern will be dictated by the location of the microphone in the cockpit and the need to detect pertinent airframe, power plant, avionics and pilots activity sounds while rejecting airflow and other extraneous sounds. The use of windscreens and isolation devices may also be necessary to ensure that ventilation airflow or airframe vibrations do not saturate the microphone input.*

I-3.3.4 Frequency Response – Microphone Preamplifier

The microphone preamplifier shall comply with the frequency response requirements listed in Table I-3.1.

NOTE: There is a significant value to the mechanical signatures that would be found below 150 Hz. However, there is also the potential for significant audio energy in this region which could saturate the recording. Therefore, it is desirable to have a second order roll off of the frequency response below 150 Hz rather than a step attenuation.

I-3.3.5 Total Harmonic Distortion plus noise – Area Microphone Preamplifier

The total harmonic distortion plus noise of the output signal shall not exceed 0.1% for input signals within the range 150 Hz to 20 kHz when measured within a 22 kHz bandwidth (un-weighted). This requirement shall be met for input signals up to the level produced by the microphone for which the equipment is designed, when it is exposed to a sound pressure level of 120 dB above 20 µPa.

I-3.3.6 Signal to Noise Ratio – Area Microphone Preamplifier

The level of any noise at the output of the preamplifier shall be as least 80 dB below the level of an output signal corresponding to the maximum input signal. This requirement shall be met for input signals up to the level produced by the microphone for which the equipment is designed, when it is exposed to a sound pressure level of 120 dB above 20 µPa.

NOTE: *The high dynamic range enables the simplification of traditional systems by removing the need for Automatic Gain Control (AGC), as well as enabling the same standard unit to transfer from the audio environment of a noisy helicopter to a quiet balloon.*

I-3.3.7 Output Level – Microphone Preamplifier

When the input level of the preamplifier signal corresponds to a sound pressure level at the microphone of 120 dB above 20 µPa, the output shall not exceed the maximum input level for which the recorder is designed.

AGC shall not be used.

Characteristic	Cockpit Area Microphone	Cockpit Area Microphone Preamplifier	Recorder Cockpit Area Microphone Channel	Recorder Pilot Audio Channel
Frequency Response (minimum)	50 Hz to 17 kHz +/- 6 dB 17 kHz to 20 kHz +/- 10 dB	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f_c) - 2nd order roll off (-12dB/octave nominal)	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f_c) - 2nd order roll off (-12dB/octave nominal)	150 Hz to 5 kHz +/- 3 dB Below 150 Hz (f_c) - 2nd order roll off (-12dB/octave nominal)
	150 Hz to 20 kHz +/- 6 dB Below 150 Hz (f_c) - 2nd order roll off (-12dB/octave nominal) See Note1			
Dynamic Range (minimum)	94dB, max input level >= 120 dB SPL	116 dB (including 36 dB of selectable attenuation)	80 dB	116dB (including 36 dB of selectable attenuation)
Selectable Input Attenuation	N/A	36 dB in 6 dB steps	none	36 dB in 6 dB steps
Signal to Noise (minimum)	67 dB referenced at 94 dB SPL	80 dB referenced to signal equivalent to 120 dB SPL at microphone	80 dB referenced to signal equivalent to 120 dB SPL at microphone	80 dB referenced to 1 Vrms input level with 0dB selectable input attenuation.
Total Harmonic Distortion and Noise (THD+N)	< 1 % (-40dB) at 120 dB SPL 22 kHz BW un-weighted	< 0.1 % (-60dB) at signal equivalent to 120 dB SPL at microphone. 22 kHz BW un-weighted	< 0.1 %(-60dB) at signal equivalent to 120 dB SPL at microphone 22 kHz BW un-weighted	< 0.1 % (-60dB) at 1 Vrms input level with 0dB selectable input attenuation, ANSI A weighting < 0.1 % (-60dB) at 4 Vrms input level with 12dB selectable input attenuation, ANSI A weighting
Audio Channel Crosstalk (minimum)	N/A	N/A	-72 dB	-72 dB
Input Impedance (minimum)	N/A	Compatible with microphone output	Compatible with preamplifier output	2000 ohm minimum
Polar Response (directivity)	As required by installation location and cockpit configuration	N/A	N/A	N/A
Output Level	Compatible with preamplifier	Compatible with recorder input	N/A	N/A
Channel Sampling Rate	N/A	N/A	44.1 kHz minimum	11.025 kHz minimum

NOTE 1: *The frequency response of the area microphone and area microphone preamplifier may be addressed as a combined value instead of individual bandwidth requirements.*

NOTE 2: *Columns represent functional boundaries and do not preclude physical combinations of these functions such as combining the preamplifier with the recorder.*

NOTE 3: *Unless otherwise noted, all specifications referenced to 1 kHz sinusoidal input.*

NOTE 4: *fc = nominal -3dB point.*

TABLE I-3.1: AUDIO QUALITY SPECIFICATION

CHAPTER I-4

MINIMUM PERFORMANCE UNDER ENVIRONMENTAL TEST CONDITIONS

I-4.1 INTRODUCTION

Chapter 2-3 of this document defines the environmental tests to be performed on the CARS.

Compliance with the applicable performance requirements of this Part for the CARS shall be demonstrated as shown in Table I-4.1.

Compliance with the applicable performance requirements of this part for the cockpit area microphone and preamplifier shall be demonstrated as shown in Table I-4.2.

I-4.2 EXCEPTIONS TO GENERAL REQUIREMENTS

The following exceptions to the general requirements defined in Chapter I-3 apply for CARS.

I-4.2.1 AF Conducted Susceptibility (Table I-4.2 – Test 17)

The area microphone preamplifier signal to noise ratio specified in paragraph I-3.3.6 may be reduced to 68 dB under this environmental test condition.

I-4.2.2 Induced Signal Susceptibility (Table I-4.2 – Test 18)

a The area microphone preamplifier signal to noise ratio specified in paragraph I-3.3.6 may be reduced to 68 dB under this environmental test condition.

b For the area microphone, the induced signal level shall not exceed a level equivalent to an applied sound pressure level of 50 dB above 20 μPa.

I-4.2.3 RF Susceptibility (Table I-4.2 – Test 19)

a The area microphone preamplifier Signal to No-Signal ratio specified in Part I may be reduced to 68 dB under this environmental condition.

b The following test levels and frequencies shall apply to the area microphone:

a. For Radiated Susceptibility. The level shall be 2V/m from 30 MHz to 8 GHz.

b. For Conducted Susceptibility. The level shall be 3 mA from 500 kHz to 400 MHz and from 500 kHz to 10 kHz shall fall at the rate of 6 dB per octave (20 dB per decade).

The RF scan may be performed at the stimulus frequency, signal level, and channel combination shown by test or analysis to have the least margin for the applicable performance requirement (refer to Table I-3.1).

ENVIRONMENT	Test Reference ED-14F/DO-160F	MOPS PARAGRAPH NUMBER						
		2-1.5 Recorder Operation	2-1.10 Time Base Stability	I-3.2.2 Channel Balance	I-3.2.3 Frequency Response	I-3.2.4 Signal/ Noise	I-3.2.5 THD + N	I-3.2.6 Audio Cross talk
Temperature	4	R	R	R	R	R	R	R
Altitude	4	R	R	R	R	R	R	R
Temp Variation	5	R	R			R	R	
Humidity	6	R				R	R	
Shock	7	R						
Vibration	8	R					R	
Magnetic Effect	15	R						
Power Input	16	R						
Voltage Spike	17	R						
AF Susceptibility	18	R					R	
Induced Susceptibility	19	R					R	
RF Susceptibility	20	R					R	
Lightning	22	R						
ESD	25	R						
Key		Blank = Manufacturer's Discretion E = Exceptions apply R = Test Required						

TABLE I-4.1: ENVIRONMENTAL TEST MATRIX FOR CARS

ENVIRONMENT	Test Reference ED-14F/DO-160F	MOPS PARAGRAPH NUMBER						
		I-3.3.1 Mic Frequency Response	I-3.3.2 Mic Frequency Distortion	I-3.3.4 Mic THD + N	I-3.3.5 Preamp Frequency Response	I-3.3.6 Preamp THD + N	I-3.3.6 Preamp Signal to Noise	I-3.3.7 Preamp Level
Temperature	4	R	R	R	R	R	R	R
Altitude	4	R	R	R	R	R	R	R
Temp Variation	5			R		R	R	
Humidity	6	R	R			R	R	R
Shock	7	R	R					
Vibration	8					R		
Power Input	16							
Voltage Spike	17							
AF Susceptibility	18						R/E	
Induced Susceptibility	19	R/E	R/E				R/E	
RF Susceptibility	20	R/E	R/E				R/E	
Lightning	22							
ESD	25							
Key	Blank = Manufacturer's Discretion E = Exceptions apply R = Test Required							

TABLE I-4.2: ENVIRONMENTAL TEST MATRIX FOR COCKPIT AREA MICROPHONE AND PREAMPLIFIER

CHAPTER I-5

TEST PROCEDURES

I-5.1 INTRODUCTION

This chapter specifies the standard test procedures for demonstrating compliance with Chapter I-2 and Chapter I-3. Although specific test procedures are cited, it is recognised that they will not apply in all cases and that other methods may be preferred or required. Alternative methods may be used if the manufacturer can show that they provide equivalent certification data.

Where a test procedure is not specified for a particular performance parameter, the manufacturer may show compliance either by analysis or by devising a test appropriate to the equipment design. All test measurements shall be traceable to a recognized calibration standard.

Traditional Cockpit Voice Recorder (CVR) systems, including the replay facilities, recorded analogue audio and reproduced analogue audio, often with little practical access to the signal or data being used between these processes.

Digital audio technology has significantly changed since early digital CVRs and become more commonly available. This standard describes a CARS in which the output is the digital data representing the audio and can be more openly accessed than with traditional CVRs. In this case, there may be little or no control over the standards of the equipment used to convert the digital data back into audible signals. The CARS described within this standard need not have an analogue audio output at all. Therefore, it may be more practical to analyse the recorded digital data against known analogue test signals rather than comparing the analogue input and output signals as per traditional test techniques.

I-5.1.1 Adjustment of Equipment

The equipment under test shall be properly aligned and adjusted in accordance with the manufacturer's recommendations.

I-5.1.2 Test Instrument Precautions

Precautions shall be taken to prevent the introduction of errors resulting from impedance mismatch and the improper connection of test instruments to the equipment under test.

I-5.1.3 Test Conditions

Unless otherwise stated, the test procedures of this chapter apply to systems with analogue inputs and analogue outputs. Where parts of the system use digital processing, the test procedures assume that interface conversion equipment appropriate to the recovery of the recorded information and which match the performance characteristics of the system to be certified, are used. Unless specified as part of environmental testing, all tests shall be performed under the conditions specified in paragraph III-3.1.

I-5.1.4 Connected Loads

Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance values for which it is designed.

I-5.1.5 Warm-Up Period

Unless otherwise specified, all tests shall be performed after a warm-up (stabilisation) period of not less than 5 minutes and not more than 15 minutes.

I-5.1.6 Recording of Test Results

Except where tests are ”Pass / Fail” in character, the actual numerical values obtained for each of the parameters tested shall be recorded in a qualification test report.

I-5.2 ELECTRICAL TEST PROCEDURES

I-5.2.1 Signal Level – Balance Between Audio Channels (if applicable) (paragraph I-3.2.2)

a Equipment Required:

Audio signal generator,

Attenuator,

Audio power meter,

Replay equipment as specified by the manufacturer.

b Measurement Procedure:

Connect and adjust the audio signal generator output to obtain half the reference signal level at each input of the recorder under test, and record this signal for a period of one minute.

Replay the recording. Choose a reference channel, and connect its output via the attenuator to the audio power meter. Adjust the attenuator to obtain a convenient reference level and note the setting. Repeat the procedure for each of the other audio channels. The balance between channels is determined by comparing the attenuator settings.

I-5.2.2 Audio Frequency Response (paragraph I-3.2.3)

a Equipment Required:

Sweep frequency audio signal generator,

Audio power meter,

Frequency counter,

Replay equipment as specified by the manufacturer.

b Measurement Procedure:

Connect the audio signal generator to one channel of the recorder under test and adjust its output to obtain a signal which continuously sweeps over the frequency range defined for this channel. Adjust the sweep frequency rate to 0.1 octave per second. Set the level to half the reference signal level at equipment input. Record this signal.

Replay the recording and measure the output level and frequency. Determine the level variation over the frequency band. Repeat the test with the input signal adjusted as appropriate to the channel under test. Where the recorded signal is reprocessed after a 30 minute period, recheck the output level and frequency, then determine the level variation over the frequency band for this condition.

I-5.2.3 Audio Noise Level – Signal to Noise (paragraph I-3.2.4)

a Equipment Required:

Audio Signal Generator,

A-weighted Filter IEC 651(1979),

3rd Octave Filters IEC 225 (1966),

Audio Power Meter,

Replay equipment as specified by the manufacturer.

b Measurement Procedure:

Operate the CARS with all flight functions and aircraft interfaces active, i.e. image, data-link, etc., and apply the reference signal to each recording channel for 30 seconds. Replay the recordings and measure the output levels using the audio power meter.

Operate the CARS with all flight functions and aircraft interfaces active, i.e. image, data-link, etc., for 30 seconds for each of the following five different input conditions – open, shorted and with three separate out-of-band signals applied. For the out-of-band tests, connect the signal generator to each channel of the recorder under test and set the input signal to the Reference Signal Level. Select, in turn, frequencies of 31.5 kHz, 40.0 kHz and 50.0 kHz for the area microphone channel, and 8 kHz, 10 kHz and 12.5 kHz for the other audio channels. Replay the recordings measuring the un-weighted 22 kHz bandwidth noise level in 3rd octave bands for the area microphone channel, and A-weighted noise level in 3rd octave bands for the pilots audio channel(s). Table I-5.1 and Table I-5.2 are examples for entering this data for the area microphone and audio channels respectively. Enter the calculated ratio in dB of the output for the reference signal input relative to the output for zero input. Record the lowest value in the last row of the table. This value should be greater than the specification given in Table I-3.1.

I-5.2.4 Signal to Total Harmonic Distortion plus Noise (paragraph I-3.2.5)

a Equipment Required:

Attenuator,

Band pass filter,

Distortion meter,

Replay equipment as specified by the manufacturer.

b Measurement Procedure:

Connect the CARS to the signal source of the distortion meter and record 1 kHz sinusoidal signals at the Reference Level to –20 dB in 5 dB steps. Replay the recordings and measure total harmonic distortion plus noise using a 90dB minimum, 3rd octave 1 kHz notch filter and a 22 kHz bandwidth, un-weighted band-limiting filter for the Area Microphone channel, and an IEC A-weighted filter for the pilots audio channel(s). Record the distortion plus noise as a power ratio, expressed in dB. This value should be greater than the specification found in Table I-3.1.

I-5.2.5 Cross-talk between Audio Channels (paragraph I-3.2.6)

a Equipment Required:

Audio signal generator,

Audio Power meter,

Replay equipment as specified by the manufacturer.

b Measurement Procedure:

With the other input channel(s) appropriately loaded, connect the signal generator to one channel of the recorder under test and adjust its output to the reference signal level. Record this signal for a period of one minute. Replay the recording and measure the signal level on each output channel. Repeat the test in turn for each input channel.

Determine the cross-talk level for each channel for each test condition.

I-5.2.6 Frequency Response – (Microphone Only) (paragraph I-3.3.1)

a Equipment Required:

Voltmeter or Level Recorder,

Audio Amplifier,

Sweep Frequency Audio Signal Generator,

Anechoic Chamber,

Replay equipment as specified by the manufacturer.

b Measurement Procedure:

Set up and calibrate the equipment in the anechoic chamber in accordance with the manufacturer's instructions. Set the output frequency to 1 kHz and the sound pressure level to 94 dB above 20 μPa at the measurement position. Connect the microphone to be tested, loaded in accordance with manufacturer's recommendation, to the audio amplifier. Monitor the output of the amplifier with the voltmeter or level recorder. Position the microphone at the calibrated reference position.

Operate a level recorder in tandem with the sweep frequency signal generator and derive a frequency response curve automatically over the range 150 Hz to 20 kHz or manually by adjusting the signal generator to frequencies of 150 Hz, 200 Hz, 350 Hz, 500 Hz, 600 Hz, 1 kHz, and then in 1 kHz steps to 20 kHz, recording the output on the voltmeter for each frequency.

Verify that the output level remains within the specified limits.

Repeat the test at a Sound Pressure Level of 60 dB above 20 μPa.

I-5.2.7 Total Harmonic Distortion plus Noise (Microphone only) paragraph I-3.3.2)

a Equipment Required:

Audio signal generator,

Voltmeter,

Audio amplifier,

Anechoic chamber,

Distortion meter,

3rd octave 1 kHz notch filter,

Replay equipment as specified by the manufacturer.

b Measurement Procedure:

Set up and calibrate the equipment in the anechoic chamber in accordance with the manufacturer's instructions. Set the output frequency to 1 kHz and the sound pressure level to 120 dB above 20 μPa at the measurement position.

Connect the microphone to be tested, loaded in accordance with the manufacturer's recommendations, to the audio amplifier. Monitor the output of the amplifier with the voltmeter and distortion meter. Position the microphone at the calibrated reference position and measure the total harmonic distortion plus noise level using a 90dB minimum, 3rd octave 1 kHz notch filter and a 22 kHz bandwidth, un-weighted band-limiting filter.

Repeat the test at a Sound Pressure Level of 94 dB above 20 μPa.

I-5.2.8 Polar Response – Area Microphone (paragraph I-3.3.3)

a Equipment Required:

Audio Signal Generator,

Power amplifier and Loudspeaker,

Voltmeter.

b Measurement Procedure:

Either in a large anechoic studio or an open space free of reflecting objects, direct a high level, 1 kHz sound towards the microphone under test. The microphone should be positioned approximately 2 metres from the loudspeaker and the level set to avoid system overloading.

Rotate the microphone and determine the polar response by measuring its output.

NOTE: *This measurement is for documentation purposes only.*

I-5.2.9 Frequency Response – (Pre-amplifier Only) (paragraph I-3.3.4)

a Equipment Required:

Audio power meter,

Audio signal generator,

Oscilloscope.

b Measurement Procedure:

Apply a 1 kHz tone to the preamplifier input to produce half the rated output level. Maintain this input level constant and vary the frequency from 22 Hz to 22 kHz frequency range and determine the maximum and minimum output levels. Simultaneously, use an oscilloscope to ensure there are no parasitic oscillations during the sweep. Determine the maximum and minimum output levels between 150 Hz and 20 kHz. Calculate the dB difference between the two levels. Calculate the slope of the high-pass filter from 22 Hz to 150 Hz. Reduce the input level to produce one tenth the rated output level and repeat the measurement.

At no time during this test shall the system be in an output limiting state. If limiting occurs, drop the input level below limiting and repeat the test. The test frequency sweep rate shall be limited to ensure that high Q system response will not be missed.

I-5.2.10 Total Harmonic Distortion plus Noise – (Pre-Amplifier Only) (paragraph I-3.3.5)

a Equipment Required:

Audio signal generator,

Audio power meter,

Distortion meter,

22 kHz band-limiting filter,

3rd octave 1 kHz notch filter.

b Measurement Procedure:

Apply a 1 kHz sinusoidal signal corresponding to the level produced by the microphone for which the equipment is designed, when it is exposed to a sound pressure level of 120 dB above 20μPa. Measure the total harmonic distortion plus noise using a 90dB minimum, 3rd octave 1 kHz notch filter and a 22 kHz bandwidth, un-weighted band-limiting filter. Record the distortion plus noise as a power ratio, expressed in dB. This value should be greater than the specification found in Table I-3.1.

I-5.2.11 Signal to Noise Ratio – (Preamplifier Only) (paragraph I-3.3.6)

a Equipment Required:

Audio signal generator,

Audio power meter,

22 kHz band-limiting filter.

b Measurement Procedure:

Apply a signal with a frequency of 1 kHz and level corresponding to the maximum rated input signal. Read the output level on power meter after passing through an un-weighted 22 kHz band-limiting filter. Disconnect the input signal and load the input with the manufacturer's recommended source impedance. Read the noise level on the power meter after passing through an un-weighted 22 kHz band-limiting filter. Determine and record the signal to noise ratio expressed in dB. This value should be greater than the specification found in Table I-3.1.

I-5.2.12 Output Level – (Preamplifier Only)(paragraph I-3.3.7)

a Equipment Required:

Audio signal generator,

True rms voltmeter,

b Measurement Procedure:

Apply an input signal with a frequency of 1 kHz and level corresponding to the level produced by the microphone for which the equipment is designed, when it is exposed to a sound pressure level of 120 dB above 20 μPa. Read the output level on the voltmeter.

Repeat the measurement for an input level corresponding to 94 dB and 70 dB above 20 μPa.

I-5.2.13 Bit Error Rate (paragraph 2-1.6)

It shall be verified that the bit error rate arising from differences between the recorded and the retrieved data caused by corruption of the data during processing, recording and retrieval does not exceed the specification in paragraph 2-1.6.

a Equipment Required:

Basic simulation of start/stop conditions,

Readout Tool, such as a computer and appropriate software, to process the recorded wav file.

b Measurement Procedure:

i. Apply power to the recording system,

ii. Set the starting conditions to true,

iii. Continue recording for duration as specified in paragraph I-1.3.2,

iv. Set the stop conditions to true,

v. Readout the recorded data,

vi. Verify bit errors or discontinuities in recovered data are within allowance of paragraph 2-1.6.

SIGNAL TO NOISE MEASUREMENT

CAM Channel

Ref. Level _____

REFERENCE LEVEL TO NOISE RATIO

Centre Frequency of 3rd Octave Band (Hz)	Output Un-Weighted Level relative to Reference Level (dB)				
	Open	Shorted	Out of Band @ Reference Level		
			31.5 kHz	40 kHz	50 kHz
200					
250					
315					
400					
500					
630					
800					
1 000					
1 250					
1 600					
2 000					
2 500					
3 150					
4 000					
5 000					
6 300					
8 000					
10 000					
12 500					
16 000					
20 000					
MINIMUM SIGNAL TO NOISE RATIO =					

TABLE I-5.1: EXAMPLE OF SIGNAL TO NOISE MEASUREMENT (PARAGRAPH. I-5.2.3)

SIGNAL TO NOISE MEASUREMENT

Pilot Channel

Ref. Level _____

REFERENCE LEVEL TO NOISE RATIO

Centre Frequency of 3rd Octave Band (Hz)	Output A-weighted Level relative to reference level (dB)				
	Open	Shorted	Out of Band @ Reference Level		
			8 kHz	10 kHz	12.5 kHz
200					
250					
315					
400					
500					
630					
800					
1 000					
1 250					
1 600					
2 000					
2 500					
3 150					
4 000					
5 000					
MINIMUM SIGNAL TO NOISE RATIO =					

TABLE I-5.2: EXAMPLE OF SIGNAL TO NOISE MEASUREMENT (PARAGRAPH I-5.2.3)

CHAPTER I-6

EQUIPMENT INSTALLATION AND INSTALLED PERFORMANCE

I-6.1 INTRODUCTION

This chapter specifies installation characteristics and performance with procedures for verifying that performance when the equipment is installed in an aircraft.

Installed performance criteria are generally the same as those contained in Chapter I-3, which were verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be confirmed after installation.

In some installations, audio system overdrive conditions may occur, resulting in clipping of waveforms. Attenuation strapping should be used to prevent overdrive conditions in any/all normal aircraft audio environments, especially during flight.

I-6.1.1 Interface Design

a Figure I-6.1 of this chapter illustrates possible CARS configurations.

b Impedance and signal levels shall be such that a satisfactory recording is obtained without unwanted coupling between the audio system microphone and telephone circuits. With all telephone inputs set to provide maximum signal to the audio but not selected to be active on the audio control panel (if installed), and with a long term rms input to the microphone, the input level at the CARS should be the long term rms level. The appropriate measures, which may include the utilization of the selectable attenuation capability of the pre-amplifier and pilots audio channel(s) inputs, shall be appropriately adjusted as determined by installation configuration.

c Hot microphone, interphone, and radio reception (if applicable)

With high volume control settings, the relative levels of the microphone and telephone signals shall be such that, at the summing point, the microphone signal exceeds the level of its corresponding sidetone signal on a high percentage of occasions.

With an input signal to the microphone equivalent to a moderate speech level (note 1) and with input to the radio reception equivalent to a strong reception signal (note 2), when volume control settings are high (note 3), the level of the recorded microphone signal (hot microphone included), shall be greater than the radio reception signal level on the majority of occasion whether interphone is in use or not.

NOTE 1: *According to ARINC 538 and D0-214 definitions, a moderate speech level (or average speech level) could be considered with SPL (Sound Pressure Level) of 98 dB (re: 20 µPa), which is around 65 mV ±3 dB.*

NOTE 2: *According to ARINC 716 definition, transceiver nominal output level could be considered as a strong level for 2.5V (10 mW on 600Ω).*

NOTE 3: *High volume control settings could be considered with a value greater than 65%.*

d Hot microphone, radio transmission, and interphone, when PTT is activated (if applicable)

The phase of any sidetone signal measured at the summing point should be within 50 degrees of the corresponding microphone signal. Where sidetone phase is uncontrolled, it is permissible for the sidetone signal to the summing point to be attenuated during radio transmissions or when interphone is selected (PTT activated). A sufficient attenuation factor will be applied in order to avoid signal cancellation effect greater than 3 dB.

e In reference to paragraphs c and d above, the hot microphone signal shall not be attenuated.

f If hot microphones are employed, then in order to maintain continuous microphone recordings by the CARS during periods when radio transmitters or interphone are not selected, an energising supply shall be provided for carbon or simulated carbon microphones. This supply may be derived from the electrical supply to the summing amplifier but shall be interrupted if and when the microphone is energised by a radio transmitter of the interphone system.

g Transients caused by microphone switching should be suppressed to avoid blocking of any recording channel.

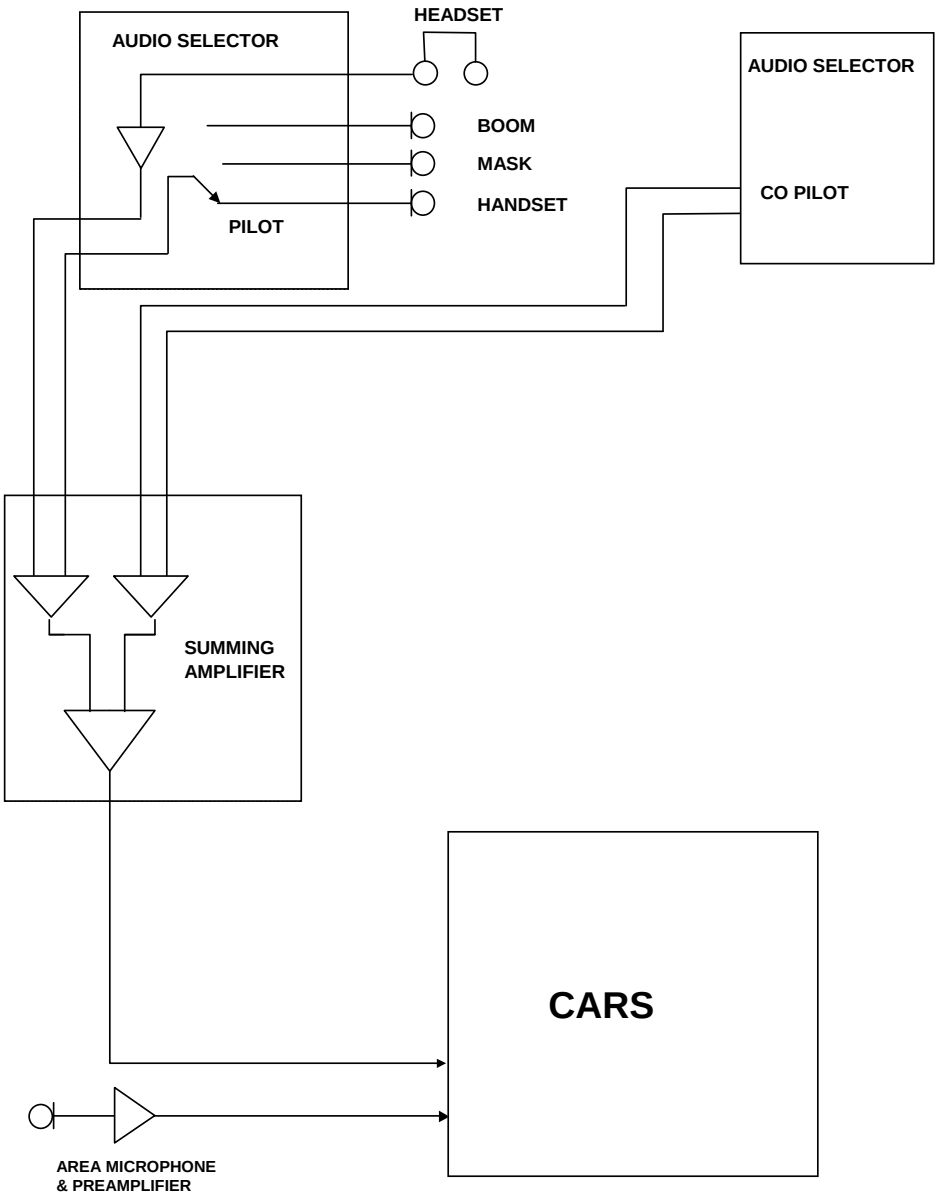


FIGURE I-6.1: EXAMPLE OF CARS INSTALLATIONS

I-6.2 EQUIPMENT INSTALLATION

I-6.2.1 Area Microphone Location

Particular attention shall be given by installers to the location of the area microphone. To aid in voice and sound discrimination, general rules for optimum performance are:

a Position the microphone for recording general cockpit sounds, voice communications originating at the pilot and co-pilot stations, voice communications of other pilots in the cockpit when directed to those stations, and for helicopters, transmission gearbox sounds. In certain cases, it may be necessary to install an additional area microphone in order to obtain adequate recordings of cockpit and/or transmission gearbox sounds.

b Correct phasing of microphones needs to be observed.

c Position the microphone to minimize noise from vents, fans, windshield wipers and other undesirable acoustic noise generators. Additionally, to minimise airstream noise, the installer should consider isolation of the microphone from structure connected to the aircraft skin.

d Position the microphone away from cockpit loudspeakers.

e Position the microphone such that it cannot be obstructed by loose articles e.g. navigation charts.

f Position the microphone such that it is unlikely to be damaged during pilots entry to, or exit from the cockpit.

NOTE: *it is recommended that the microphone is not installed on the lower centre console.*

I-6.2.2 Bulk Erase Control

The installation of a bulk erase control should be designed to prevent activation during flight and to minimize any inadvertent operation during a crash impact.

I-6.2.3 Quality of Recording

For the first installation of a new combination of equipment and airframe the quality of the recording shall be established by analysis of information recorded on the ground and in flight. The replay and evaluation will need to be performed after the flight test. If mandated by the Certification Authority, verification of the flight test recording shall be performed by an approved readout and replay centre.

I-6.3 GROUND TEST PROCEDURES

I-6.3.1 General

This section provides guidance for ground testing prototype installations. It may need to be adapted to suit the particular installation configuration being tested and to comply with operating regulations.

I-6.3.2 Conformity Inspection

a Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices.

b Verify that proper mechanical and electrical connections have been made and that the equipment has been located and installed in accordance with the requirements and the manufacturer's recommendations.

I-6.3.3 Interference Effects

a With the recording equipment in normal and standby operation, operate other electrically operated aircraft equipment and systems to determine that no significant levels of conducted or radiated interference exist.

b Evaluate all combinations of control settings and operating modes.

c Operate communication and navigation equipment on the low, high and at least one mid-band frequency.

d Identify systems or modes of operation that should be evaluated during flight.

e If appropriate, repeat the tests using emergency power with the aircraft's batteries alone and any standby inverters operating.

I-6.3.4 Power Supply Fluctuations and Protection

a Under normal aircraft conditions, cycle the aircraft engine(s) through all normal power settings and verify the proper operation of the equipment.

b Isolate the electrical supply to the recording system by means of the protective devices provided (e.g. circuit breakers) and verify that the equipment is off.

I-6.4 FLIGHT TEST PROCEDURES

I-6.4.1 General

a This section provides guidance for flight testing prototype installations. It may need to be adapted to suit the particular installation configuration being tested and to comply with operating regulations.

b Each newly installed CARS shall be flight tested, and the recording so obtained shall be evaluated to show adequate recording quality during all normal regimes of flight including taxiing, takeoff, cruise, approach and landing. For helicopters, hover and autorotation should be included.

c Since the duration of the recording may be limited, the test flight should be carefully planned. The CARS circuit breaker can be tripped between each test phase and at the end of the landing run if the flight is likely to exceed the recording duration limit.

d Systems which generate sounds in the cockpit and which might not otherwise be used during the test flight, should be operated with appropriate announcements by the pilots.

e To enable proper analysis of the recording, it is essential that adequate commentary on the flight is provided, e.g. pilots actions, altitudes and speeds. Each test should be clearly announced and the pilot identified, e.g. “Co-pilot testing oxygen mask microphone with interphone off”.

f If mandated by the certification authority, verification of the flight test recording shall be performed by an approved read-out and replay centre. Refer to Annex I-A.

I-6.4.2 Prior to Engine Start

a Check that the CARS is operating.

b Press the ERASE button (if fitted).

c Confirm CARS Serviceability e.g. by pressing the CARS TEST button.

d Select BOOM microphone and interphone ON at all pilots stations.

e Identify each pilot, the aircraft type and registration, date and time.

f Call out the location of the area microphone e.g. centre pedestal, overhead panel, glare shield.

I-6.4.3 Engine Start

a (Helicopters only). During rotor spin-up, call out main rotor speed at 50%, 80% and 100%.

b Make a test announcement from each pilot's station in turn using the boom microphones with interphone selected ON followed by a second announcement with the interphone OFF, i.e. "hot microphone" function.

c Repeat paragraph I-6.4.3b using the oxygen mask microphone (if applicable).

d (Aeroplanes only). Announce and test the stall warning stick shaker if installed.

e Close the cockpit windows.

I-6.4.4 Takeoff

a With headsets on and boom microphones in position for use, record a normal takeoff and initial climb.

b Announce landing gear and flap selections and propeller settings (where applicable).

I-6.4.5 Cruise

a With interphone OFF at all stations, announce and activate aural warnings.

b (Aeroplanes only). Where regulations permit, accelerate to, and announce VMO. Continue until the overspeed warning sounds if installed. Reduce speed as required.

c Perform a VHF test transmission from each pilot's station using boom microphones. (VHF audio should be selected OFF at all other pilots stations).

d Perform a VHF test transmission from each pilot's station using hand-held microphone and the cockpit loudspeakers. (VHF audio should be selected OFF at all other pilot stations).

e Perform a test transmission from each pilot's station using HF (if fitted) and boom microphones. (HF audio should be selected OFF at all other pilot stations).

f Perform test broadcasts from the cockpit and the cabin using the passenger address system.

g (Helicopters only) Call out rotor RPM.

h Announce and open the cockpit-cabin door. Announce and close the door after approximately 10 seconds.

i Where permitted, announce and open the cockpit windows. Announce and close the windows after approximately 10 seconds.

j Where available, acknowledge verbally, a digital message received via the digital data-link system.

I-6.4.6 Helicopter Auto-Rotation and Hover

a At a safe altitude, perform an auto-rotation descent with power recovery.

b Announce and hover for approximately 20 seconds.

I-6.4.7 Landing

a Record final approach and landing including ILS and Marker audio identification. Announce landing gear and flap selection and other actions.

b At end of landing run call out the time.

c Select BOOM microphone and interphone ON at all pilot stations and announce “End of Audio Recorder Test”.

d DO NOT ERASE (if fitted).

e Remove aircraft power from the CARS.

I-6.4.8 Follow-On CARS Installations

There is no requirement for dedicated ground or flight test, however following installation, recorded flight data should be reviewed to confirm functionality at the earliest opportunity.

ANNEX I-A

POST FLIGHT EVALUATION OF RECORDINGS

I-A.1 INTRODUCTION

I-A.1.1 Following the flight testing of each new CARS installation type, 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 audio environment, to ensure that quality is maintained.

I-A.1.2 It is recommended that the replay equipment be located in a clean, quiet area which is separated from other work areas sufficiently to ensure the privacy of recordings and to protect other staff from exposure to irritating noise. Access to the replay equipment should be restricted to authorised personnel only.

I-A.1.3 Provision shall be made for the secure storage of CARS recording media and any copies made.

I-A.1.4 The replay and evaluation of recordings shall be performed by personnel with adequate knowledge of CARS and aircraft operations, and who have appropriate experience of the techniques used to evaluate recordings.

I-A.1.5 The recording evaluated shall be the original recording that is stored in the robust memory module.

***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 pilots on a CARS test flight in order to become familiar with the test procedure.*

I-A.1.6 A test report and certification in a format acceptable to the certification authority shall be required to record the observations made from evaluation of the recording.

I-A.2 REPLAY EQUIPMENT

I-A.2.1 Experience has shown that a multi-channel replay method re-creates the flight conditions with a measure of realism which assists subjective evaluation of the recording. For this reason, the evaluation of recordings from new CARS installations should involve replay on equipment capable of multi-channel reproduction.

I-A.2.2 The recording should be replayed for qualitative review and analysed quantitatively to check recorded signal levels.

I-A.3 RECORDING EVALUATION

I-A.3.1 The recording on each channel shall be checked to confirm that the required input sources are connected to the CARS system, and that recorded levels and signal quality are acceptable.

I-A.3.2 In general, the proper recording level will be confirmed to show that the full recording dynamic range has been achieved without clipping of peak signals. A check should be made to confirm that adequate signal to noise ratios exist for all significant input signals, and that signal levels are reasonably balanced between the channels. Signal quality may be confirmed during subjective listening checks and by ensuring that the recording is free from electrical interference and from the effects of vibration. The presence of cockpit sounds, pilots speech and audible warnings should be confirmed on the area microphone channel.

***NOTE 1*:** *A low level of AC power interference may be tolerated.*

***NOTE 2*:** *To avoid signal cancellation effects, and to ensure that incoming radio messages do not mask pilots speech, with a moderate speech level (refer to paragraph I-6.1.1) levels of telephone signals, at high volume control settings (greater than 65%), should be preset lower than the CARS hot microphone signal level.*

I-A.3.3 For combined CARS and ADRS, flight data recordings may be verified by correlating data values against announcements made by the pilots, and by ensuring that the parameter range and resolution available are sufficient to meet the specified range/accuracy requirements.

***NOTE*:** *Further verification of data accuracy may be required by the certification authority. This aspect of data verification is the subject of Part II of this document.*

I-A.4 TEST REPORT

I-A.4.1 A suitable report is shown in Table I-A.1. This will need to be tailored to match the aircraft installation configuration. The report may be supplemented by graphic evidence obtained from selected extracts of the recording.

I-A.4.2 The spaces on the report, as applicable, should be annotated with brief comments on the replay signal quality.

ABC AVIONICS
Municipal Road
TOONVILLE

CERTIFICATE NO _____

TEST CERTIFICATE

COCKPIT AUDIO RECORDING SYSTEM - FLIGHT TEST EVALUATION

AIRCRAFT TYPE: ..... REGN: .... OPERATOR: .....

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

RECORDING QUALITY CHECK			
INPUT CHANNEL	1	2	3
FUNCTION			
MICROPHONES HOT-MIC BOOM			
HOT-MIC MASK			
HOT-MIC LEVELS			
TELEPHONES / PA RADIO RECEPTION			
RADIO SIDETONE			
INTERPHONE			
PUBLIC ADDRESS			
WARNINGS			
SIGNAL LEVEL			
AREA MIC COCKPIT SOUNDS			
WARNINGS			
SIGNAL LEVEL			

REMARKS .....

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 ABC Avionics

Organisation Approval Reference .....

TABLE I-A.1: EXAMPLE OF CARS TEST REPORT

ANNEX I-B

MAINTENANCE PRACTICES

I-B.1 GENERAL

I-B.1.1 The maintenance tasks required to ensure the continued serviceability of the installed CARS will depend on the extent of monitoring built into the CARS. Appropriate inspections and functional checks, together with the intervals at which these should be performed are described in Table I-B.1.

I-B.1.2 Maintenance procedures should emphasise the need to preserve the recording following a reported incident.

I-B.2 RECORDING EVALUATION

I-B.2.1 An in-flight recording should be replayed and assessed for quality. Annex I-A provides guidance for the evaluation of such recordings.

I-B.3 PRIMARY MAINTENANCE TASKS

Table I-B.1 shows the primary maintenance tasks for the installed CARS.

Item	Task	Maximum Interval	Interpretation
1	Operational Check	Daily or prior to each flight	Confirm serviceability using TEST function on CARS controller or Check ‘no-fail’ indication for built in test
2	System check and replay	As agreed between operator and regulatory authority (24 months recommended)	Carry out a lossless download of the CARS recordings immediately post-flight. Replay and evaluate the quality of the in-flight recording.

TABLE I-B.1: MAINTENANCE TASKS AND INTERVALS

PART II

AIRCRAFT DATA RECORDING SYSTEMS

CHAPTER II-1

INTRODUCTION

II-1.1 PURPOSE AND SCOPE

II-1.1.1 General

This part defines the minimum specification to be met for an Aircraft Data Recording System. This Part shall be read in conjunction with Sections 1 and, 2 together with Section 3 if applicable.

II-1.1.2 Description of Content

This part is divided into six Chapters and three Annexes.

Chapter II-1 describes typical equipment applications and operational objectives. Background material and accident investigation considerations are included together with a description of the ADRS.

Chapter II-2 defines the general design specification.

Chapter II-3 defines the minimum system performance under standard test conditions.

Chapter II-4 defines the minimum system performance under environmental test conditions.

Chapter II-5 specifies tests and procedures for determining compliance with the performance requirements.

Chapter II-6 defines the installed equipment performance requirements including ground tests and flight tests.

The Annexes provide details of the documentation to be provided, parameters to be recorded and give additional guidance on maintenance practices and electronic documentation standards.

II-1.2 APPLICATION

II-1.2.1 Aircraft Data Recording System

Compliance with this Part will ensure that the ADRS will perform its intended function under the conditions encountered in aircraft operations.

II-1.3 DESCRIPTION OF THE SYSTEM

II-1.3.1 Equipment

The ADRS may include the following equipments as appropriate to the aircraft.

a. Equipment necessary to acquire and process analogue and digital sensor signals.

b. A robust recorder in which it is recommended that the recording be synchronised with the other airborne recording systems and UTC,

c. Equipment when necessary to support dedicated sensors, store the recorded data in a robust recording medium, and, when necessary, support dedicated sensors.

d. Digital data busses or networks providing communications between elements of the system.

II-1.3.2 Operational Considerations

a. Objectives

Each ADRS should be installed so as to provide, with reference to a timescale, a recording of aircraft parametric data.

b. Start and Termination of Recording

Recorder operation shall be as defined in paragraph 2-1.5.

CHAPTER II-2

ADRS DESIGN SPECIFICATION

II-2.1 EQUIPMENT DESIGN SPECIFICATION

II-2.1.1 General

This section is applicable to the functions of a flight recording system designed to receive, process, record and preserve flight data in accordance with the requirements of this MOPS. These functions shall be performed reliably even under adverse operating conditions including events leading to an accident.

This section shall be read in conjunction with Section 2, which defines the requirements that are generic to all flight recording systems.

II-2.1.2 Recording Techniques

a. The ADRS shall use a digital method of recording and storing the data in a robust memory module.

b. Data shall be recorded in a format that is easily identified and can be decoded with reference to the documents specified in paragraph 2-1.3.4d.

c. Data compression shall not be used.

II-2.1.3 Recording Capacity and Format

The ADRS shall be capable of retaining the data recorded during at least the last 25 hours of its operation.

The equipment shall be capable of recording in digital format the data parameters specified in Annex II-B of this section.

II-2.1.4 Means of Access to Recorded Information

The means for accessing the recorded information shall:

a. not erase, re-write or alter the recording,

b. utilise a standard computer interface for lossless retrieval of all data,

c. not require the removal of the robust memory module from its location in the aircraft, and

d. allow accident investigation authorities unrestricted access to the data.

NOTE: *It is not required for the ADRS to continue to record information whilst the recorded data is retrieved.*

II-2.1.5 Recording Delay

The delay between the completion of the data acquisition process and the recording of the resulting data in the robust recording medium shall not exceed 1 second.

NOTE: *It is important to preserve all available data. For this reason, any delay should be minimised.*

II-2.1.6 Self Monitoring of Proper Operation

a. Means shall be provided, as far as is practicable, to detect the loss of the data from sensors connected to the aircraft data recording system and causing a fault indication.

b. When the ADRS provides an excitation voltage for dedicated ADRS sensors, a means of detecting and reporting when this signal is not available shall be provided.

NOTE 1: *Except where sensor unserviceability would be detectable by other means, a aircraft data recording system maintenance indicator should be set.*

NOTE 2: *Where sensor data is not monitored and where the sensor unserviceability would remain undetected or would not be evident to the pilots, a maintenance task should be specified to check, at appropriate intervals, that the sensor is operating within its specified limits and that data is being supplied to the recorder.*

NOTE 3: *Except where the overall performance of the recording system would be adversely affected, data from a defective sensor should continue to be recorded.*

II-2.1.7 Data to Be Recorded

a. Data shall be recorded within the range, resolution, accuracy and sampling intervals specified in Annex II-B.

b. Any novel or unique design or operational characteristics of the aircraft shall be evaluated to determine if any dedicated parameters should be recorded in addition to or in place of existing requirements.

c. Data should be obtained from sources which provide accurate and reliable information under both static and dynamic conditions.

II-2.1.8 Erasure of Recorded Data

a Except for the overwriting of the oldest data by new information, no means for the erasure of the recorded data shall be provided in the recording system.

NOTE: *It is understood that military organisations may use commercial recorders. In this case, they may have additional security requirements that exempt the recording system from this requirement. Arrangements should be made with the appropriate certification authority in regard to such exemptions.*

b It is recommended that appropriate procedures are used to avoid the over-writing of data during aircraft maintenance following a reportable incident or accident.

II-2.1.9 Quality and Reliability of Recording

a For each newly installed system, the performance of the system and quality of recorded data shall be established by analysis of data recorded on the ground and in flight.

b It is recommended that the relevant accident investigation authority should be invited by the certification authority to participate in the assessment of new systems and the quality of the recorded data particularly where novel features exist (refer to paragraph II-2.1.7).

II-2.1.10 Means of Functional Test

A means shall be provided for checking the recording system for proper operation as required by the paragraph II-2.1.6 of this part and paragraph 2-1.4 of Section 2 (Common Design Specifications).

II-2.1.11 Acceleration Sensors

The damping factor of the acceleration sensors shall be not less than 0.7 of critical damping and the total error in following a single triangular input of 0.5 second duration or greater, shall be no more than 10% of the acceleration. The input/output ratio shall not vary by more than ± 3 dB when the sensor is subjected to a sinusoidal acceleration input whose frequency is greater than 0 and less than 4 Hz (for an 8 Hz sampling rate minimum). Above 4 Hz (for an 8 Hz sampling rate minimum), the output signal shall decrease at not less than 6 dB per octave.

To avoid aliasing the roll off frequency should be consistent with the sampling rate of accelerations.

II-2.1.12 Data Sampling, Recording and Retrieval Characteristics

II-2.1.12.1 Data Sampling

Successive recorded values of each parameter shall be derived from new readings obtained from the input interface of the ADRS. Irrespective of the parameter, readings shall be recoverable in the sequence in which they were made.

II-2.1.12.2 Data Recording Range

As a minimum, the recording range for parameters shall comply with the range defined in the tables of Annex II-B.

II-2.1.12.3 Data Accuracy, Resolution and Timing

a Data shall be recorded so as to meet the minimum sampling, recording interval, accuracy and resolution requirements as defined in the tables of Annex II-B.

b The interval between successive readings of a parameter shall meet that specified in the parameter tables and be consistent in time to within a tolerance of 1/64th of a second.

c Data shall be recorded so that relative timings between parameters can be deduced within a tolerance of 0.25 seconds.

NOTE: *This tolerance should refer to the timing of actual events not acquisition time.*

CHAPTER II-3

MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD TEST CONDITIONS

II-3.1 INTRODUCTION

This chapter provides the minimum performance specification of the equipment and the levels to be demonstrated under standard test conditions.

II-3.1.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F. "Environmental Conditions and Test Procedures for Airborne Equipment", paragraph 3.5 as:

a Temperature : +15 to +35°C

b Relative Humidity : Not greater than 85%

c Ambient Pressure : 84 to 107 kPa

In addition to the above, the electrical power supply shall be within the limits specified as Normal in Section 16 of ED-14F/DO-160F or subsequent issue.

In the case of equipment designed for operation from an AC power source of variable frequency, unless otherwise specified, tests should be performed at representative input power frequencies with the input frequency adjusted to within 5% of a selected frequency.

II-3.2 RECORDING SYSTEM MINIMUM PERFORMANCE LEVELS

The recording system shall be tested to show compliance with the following minimum performance levels.

NOTE: *Where these paragraphs state requirements regarding the information in the recording medium, it should be interpreted as that observed at the output of the data retrieval equipment specified by the equipment manufacturer.*

II-3.2.1 Start-up and Effects of Power Interruptions

Following a system electrical power interruption, the characteristics of the ADRS (including any networks, busses etc) shall be such that:

a Following initial application of power to the recording system and any start logic is satisfied, or following an interruption with duration of more than 2 seconds, the recording system shall commence and continue to store information, in accordance with the requirements of this MOPS, within 1 minute.

b At normal power levels, interruptions with duration of 200 milliseconds or less shall have no effect on the recorder.

c All information available at the start of an interruption together with that available in the following 200 milliseconds shall be recorded in the robust memory module.

d At normal, abnormal, and emergency power levels, for interruptions with a duration of more than 200 milliseconds and less than 2 seconds, the system shall recover and commence storing data within the recording medium within 1 second after power is restored, except that any built in test function may recover within ten seconds after power is restored.

***NOTE*:** *The recording of data should commence immediately when data is available irrespective of the status of any synchronisation feature.*

CHAPTER II-4

MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS

II-4.1 INTRODUCTION

Chapter 2-3 of this document defines the environmental tests to be performed on the ADRS.

Compliance with the applicable performance requirements of this part for the ADRS shall be demonstrated as shown in Table II-4.1.

II-4.2 EXCEPTIONS TO GENERAL REQUIREMENTS

There are no exceptions to the general requirements defined in Chapter II-3 for ADRS.

ENVIRONMENT	ED-14F/DO-160F section	MOPS PARAGRAPH NUMBER				
		2-1.5	2-1.6	2-1.10	II-3.2.1	II-2.1.5
		Normal operation	Bit Error Rate	Time base Stability	Power Interruption	Recording Delay
Temperature	4	R	R	R	R	R
Altitude	4	R			R	
Temp. variation	5	R				
Humidity	6	R				
Shock	7	R				
Vibration	8	R				
Magnetic Effect	15	R				
Power Input	16	R				
Voltage Spike	17	R				
AF Susceptibility	18	R				
Induced Susceptibility	19	R				
RF Susceptibility	20	R				
ESD	25	R				
RF Emission	21	R				
KEY	Blank = Manufacturer's discretion R = Test Required					

TABLE II-4.1: ENVIRONMENTAL TEST MATRIX FOR ADRS

CHAPTER II-5

TEST PROCEDURES

II-5.1 INTRODUCTION

This chapter specifies the standard test procedures for demonstrating compliance with Chapter II-2 and Chapter II-3. Although specific test procedures are cited, it is recognised that they will not apply in all cases and that other methods may be preferred or required. Alternative methods may be used if the manufacturer can show that they provide equivalent certification data.

Where a test procedure is not specified for a particular performance parameter, the manufacturer may show compliance either by analysis or by devising a test appropriate to the equipment design. All test measurements shall be traceable to a recognized calibration standard.

II-5.1.1 Adjustment of Equipment

The equipment under test shall be properly aligned and adjusted in accordance with the manufacturer's recommendations.

II-5.1.2 Test Instrument Precautions

Precautions shall be taken to prevent the introduction of errors resulting from impedance mismatch and the improper connection of test instruments to the equipment under test.

II-5.1.3 Test Conditions

Unless otherwise stated, the test procedures of this chapter apply to systems with analogue inputs and analogue outputs. Where parts of the system use digital processing, the test procedures assume that interface conversion equipment appropriate to the recovery of the recorded information and which match the performance characteristics of the system to be certified, are used. Unless specified as part of environmental testing, all tests shall be performed under the conditions specified in paragraph II-3.1.

II-5.1.4 Connected Loads

Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance values for which it is designed.

II-5.1.5 Warm-Up Period

Unless otherwise specified, all tests shall be performed after a warm-up (stabilisation) period of not less than 5 minutes and not more than 15 minutes.

II-5.1.6 Recording of Test Results

Except where tests are ”Pass / Fail” in character, the actual numerical values obtained for each of the parameters tested shall be recorded in a qualification test report.

II-5.2 ELECTRICAL TEST PROCEDURES

II-5.2.1 Bit Error Rate (paragraph 2-1.6)

It shall be verified that the bit error rate arising from differences between the recorded and the retrieved data caused by corruption of the data during processing, recording and retrieval does not exceed the specification in paragraph 2-1.6.

a Equipment Required:

Basic simulation of start/stop conditions,

Readout Tool, such as a computer and appropriate software, to process the recorded data.

b Measurement Procedure:

Apply power to the recording system and set the starting conditions to true. Continue recording for the duration specified in paragraph II-2.1.3. Set the stop conditions to true and readout the recorded data. Verify that bit errors or discontinuities in recovered data are within the allowance of paragraph 2-1.6.

CHAPTER II-6

EQUIPMENT INSTALLATION AND INSTALLED PERFORMANCE

II-6.1 INTRODUCTION

This chapter specifies ADRS installation characteristics and performance with procedures for verifying that performance when the system is installed in an aircraft. Installed performance criteria are generally the same as those contained in Chapter II-3, which were verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be confirmed after installation.

II-6.2 EQUIPMENT INSTALLATION

II-6.2.1 Acceleration Sensors

Acceleration data shall be obtained from sensors which are rigidly attached. When practicable these sensors should be aligned with aircraft main axes.

Sensor location and alignment should be documented.

II-6.3 INSTALLATION CALIBRATION AND CORRELATION TESTS

II-6.3.1 General

A schedule of tests should be prepared by the equipment installer. For the prototype installation, a comprehensive programme of tests should be performed, as described in paragraph II-6.4.

II-6.3.2 Installation Tests

Proper functioning of a newly installed ADRS may be determined by a combination of ground and flight tests. Ground testing should confirm the accuracy of recorded parameters throughout their whole operational range where practicable. The flight test should validate the consistency of the recorded data with indications in the cockpit.

II-6.4 INITIAL AIRCRAFT DATA RECORDING SYSTEM INSTALLATION

The following tests shall be performed for certification of an initial ADRS installation.

a With the ADRS operating, perform a calibration check of all parameters and discretes. All sensors or transducers 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.

b Sensors which may not be practical to exercise or stimulate for the purpose of calibration tests (e.g. airspeed and altitude) may be simulated by appropriate test equipment.

c Each calibration point should be predetermined and tabulated on a calibration record sheet. The calculated value for each calibration point should be shown on the record sheet and the test operator should enter the value of the recorded data.

d Where the output of a sensor is indicated on cockpit instruments and/or displays, the correlation between the indicated value and the predetermined calibration point should be established.

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

f The number of correlation or test points for non-linear parameters must be sufficient to precisely define the relationship between the recorded value and measured value over the full operating range of the parameter within the accuracy required by Table II-B.1. The correlation between recorded and measured values for linear parameters can be established with three test points, one at the mid or null point and the others at each end point of the operating range. 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 cockpit controls having discrete detent positions (e.g. throttles, flaps), each detent position should be tested.

II-6.5 GROUND TEST PROCEDURES

II-6.5.1 General

This section provides guidance for ground testing prototype installations. It may need to be adapted to suit the particular installation configuration being tested and to comply with operating regulations.

II-6.5.2 Conformity Inspection

a. Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices.

b. Verify that proper mechanical and electrical connections have been made and that the equipment has been located and installed in accordance with the requirements and the manufacturer's recommendations.

II-6.5.3 Equipment Function

Vary all controls of the equipment through their full range to determine that the equipment is operating according to the manufacturer's instructions and that each control performs its intended function.

II-6.5.4 Interference Effects

a With the recording equipment in normal and standby operation, operate other electrically operated aircraft equipment and systems to determine that no significant levels of conducted or radiated interference exist.

b Evaluate all combinations of control settings and operating modes.

c Operate communication and navigation equipment on the low, high and at least one mid-band frequency.

d Identify systems or modes of operation that should be evaluated during flight.

e If appropriate, repeat the tests using emergency power with the aircraft's batteries alone and any standby inverters operating.

II-6.5.5 Power Supply Fluctuations and Protection

a Under normal aircraft conditions, cycle the aircraft engine(s) through all normal power settings and verify the proper operation of the equipment.

b Isolate the electrical supply to the recording system by means of the protective devices provided (e.g. circuit breakers) and verify that the equipment is off.

II-6.6 FLIGHT TESTS

The flight test should validate the consistency of the recorded data through the use of cockpit indications.

The flight test shall be performed after the ground test and while it should be of minimal duration, should nevertheless be of sufficient length to determine if there has been any degradation of the recorded data when compared with the ground correlation and calibration data and to validate all parameters that can only be exercised during the aircraft's in-flight (dynamic) condition.

The certification flight test of the initial ADRS installation shall include specific test points of all parameters and should cover takeoff, climb, cruise, descent, approach and landing. The test schedule should include test points for the following where practicable:

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 ground tests, functioning of the equipment and systems in all modes and over their full ranges to generate the various discretes and variable parameters to be recorded.

c Operation of radio transmitters and electrical equipment (e.g. pumps, solenoids, motors, fans) to demonstrate ADRS immunity to electromagnetic interference.

d For the assessment the raw recorded data shall be converted to engineering units using the information contained in the certification document specified in paragraph 2-1.3.4d. The assessment shall then be carried out on this converted data.

II-6.7 FOLLOW-ON ADRS INSTALLATIONS

There is no requirement for dedicated ground or flight test, however following installation, recorded flight data should be reviewed to confirm functionality at the earliest opportunity.

ANNEX II-A

REQUIRED DOCUMENTATION

II-A.1 TO SUPPORT CERTIFICATION AND INSTALLATION OF THE ADRS:

a. A report prepared to comply with the requirements shall describe the ADRS installation and the equipment installed and shall contain a record of the results of all ground and flight tests, including calibrations and correlations. A copy of the actual ground and flight test data shall be retained by the installation approval holder.

b. Any processing time delays between the aircraft data recording acquisition system input and aircraft data recording output shall be documented.

II-A.2 TO SUPPORT INTERPRETATION OF THE RECORDING FORMAT OF THE ADRS:

Because ADRS documentation is necessary for the recovery of aircraft data recording information, the progress of an investigation can be significantly hindered if there are any delays in recovering the recorded information. This will not only delay determination of the cause, but also slow down the identification of critical safety issues. ADRS documentation is currently maintained in a variety of electronic and hard copy formats that are often incomplete or difficult to interpret.

a A description of the file structure and naming convention for the recording in the robust memory device shall be in a commonly readable format, such as ASCII encoding, and stored separately within the robust memory device.

b In order to convert raw recorded data into engineering units, the following information shall be documented for each parameter. This documentation shall be in a commonly readable format, such as ASCII encoding, and stored separately within the robust memory medium:

i. Parameter Name

ii. Information needed to locate the parameter samples in the data recording

iii. Minimum and maximum raw recorded values

iv. Algorithm(s) required to be applied to the raw recorded values in order to convert them into engineering units

v. Units (e.g. degrees, feet, knots)

vi. Discrete Interpretation (e.g. 1 = Engaged, 0 = Disengaged)

vii. Sign Convention (e.g. positive values = aircraft nose-up)

viii. When available, timing information including any processing time delays between sampling at the sensor and recording in the robust memory device

c The documentation held in the robust memory medium shall be maintained so as to reflect accurately the functionality of the recording system.

II-A.3 EXAMPLE OF AN ELECTRONIC DOCUMENTATION STANDARD

The ARINC FRED (Flight Recorder Electronic Documentation) format 647A qualifies as an international standard for documenting the content and format of information retained in FDRs. The FRED format 647A is not a standard for the data, but a standard for the documentation that a ground station needs to recover the data. The ARINC FRED format 647A - Flight Recorder Electronic Documentation have been designed and developed to provide a standardised format for maintaining and conveying FDR system documentation.

A brief description of the standard and the full document can be obtained on ARINC website at https://www.arinc.com/cf/store/catalog_detail.cfm?item_id=673.

NOTE: *This documentation is not intended to replace the system descriptions that manufacturers currently produce. These normally contain much greater information about the system that is of use to investigators.*

ANNEX II-B

DEFINITION OF PARAMETERS TO BE RECORDED

II-B.1 PARAMETER TABLES

Table II-B.1 provides details of parameter characteristics appropriate to ADRS. Parameters annotated with an “E” are of primary importance for accident investigation and shall be recorded in order to comply with this MOPS. Parameters annotated with an “R” should be recorded if practicable.

***NOTE 1*:** *Where spare capacity exists, manufacturers and operators should be encouraged to use the space to increase sampling rates or resolution or to record additional parameters for operational use.*

NOTE 2 *Where practicable, spare input ports to the acquisition system should also be mapped to the data frame.*

II-B.2 RECORDING FORMAT

The data shall be recorded in either raw data or converted engineering unit format.

If the engineering unit converted format is used, the information shall be in a commonly readable format, such as ASCII encoding and shall comply with range, accuracy and resolution requirements detailed in Table II-B.1. The recording format used, including parameter timing information, shall be fully documented and stored on the robust memory device.

Provision may need to be made for the recording of documentary parameters which might be needed as an aid to data retrieval, conversion and analysis. For example, it might be necessary to include in the recording, parameters to identify airframe and system configuration including the software standard associated with data acquisition.

When creating a data frame the following points should be considered:

a Certain parameters need to be recorded at equal time intervals to aid computer processing during accident analysis e.g. accelerations, attitude.

b Related parameters such as the acceleration on 3 axes or parameters from an engine should be sampled and recorded as close together in time as possible.

II-B.3 RECORDING RANGE

Reference in Table II-B.1 to the term "full range" is to be interpreted as the operational range of the parameter appropriate to the aircraft in question (e.g. the total angular movement of a control surface) irrespective of the range available from the associated transducer or the magnitude of the word on a data bus. A margin for abnormal conditions may need to be provided, e.g. excess speed.

II-B.4 RECORDING INTERVAL

The figure given for each parameter Table II-B.1 in is the maximum time interval in seconds between two consecutive readings. The requirements relating to time correlation between sampling and recording are specified in paragraphs II-2.1.12.1 and II-2.1.12.3b.

II-B.5 RECORDING ACCURACY

The recorded parameter accuracy shall be at least the accuracy specified in Table II-B.1.

In this context, the term ‘recording accuracy’ refers to the correctness of the recorded data in relation to the physical value.

The recorded parameter accuracy applies only to the sensor through the recorded data and does not apply to items upstream of the sensor.

When the accuracy is given as a percentage, the percentage will apply to the operational range of the parameter as opposed to the total range of the sensor.

II-B.6 RECORDING RESOLUTION

The resolution required for each parameter is listed in Table II-B.1. Resolution typically refers to the value of the least significant bit (LSB) as recorded by the system. The resolution should be such that it does not compromise the accuracy of the parameter (resolution should be an order of magnitude better than the required parameter accuracy).

Parameter name	Fixed wing	Rotary wing	Sail plane	Lighter than air	Piston engine	Turbine engine	Minimum Recording Range	Maximum recording interval in seconds	Minimum Recording Accuracy	Minimum Recording Resolution	Remarks
Relative time count	**E**	**E**	**E**	**E**	**E**	**E**	0 to 4095	1	± 1 sec per hour	1 second	
Heading (Magnetic or True)	R*	R*	R*				± 180°	1	± 2°	0.5°	* If not available, record rotational rates
Pitch attitude	**E***	**E***	**E***	R*			± 90°	0.25	± 2°	0.5°	* If not available, record rotational rates
Roll attitude	**E***	**E***	**E***	R*			± 180°	0.25	± 2°	0.5°	* If not available, record rotational rates
Yaw rate	**E***	**E***	**E***	R			± 300°/sec	0.25	± 1% + drift of 360°/hr	2°/sec	* Essential if no heading available
Pitch rate	**E***	**E***	**E***	R			± 300°/sec	0.25	± 1% + drift of 360°/hr	2°/sec	* Essential if no pitch attitude available
Roll rate	**E***	**E***	**E***	R			± 300°/sec	0.25	± 1% + drift of 360°/hr	2°/sec	* Essential if no roll attitude available
Positioning system : Latitude/Longitude	**E**	**E**	**E**	**E**			Latitude:±90° Longitude:±180°	2 (1 if available)	As installed (0.00015° recommended)	0.00005°	
Positioning system estimated error	**E***	**E***	**E***	**E***			Available range	2 (1 if available)	As installed	As installed	* If available
Positioning system : altitude	**E**	**E**	**E**	**E**			- 1 000 ft to maximum certificated altitude of aircraft + 5 000 ft	2 (1 if available)	As installed (±50 ft recommended)	5 ft	
Positioning system : time*	**E**	**E**	**E**	**E**			24 hours	1	±0.5 second	0.1 second	* UTC time preferred where available.
Positioning system : ground speed	**E**	**E**	**E**	**E**			0 - 1000 kt	2 (1 if available)	As installed (±5 kt recommended)	1 kt	
Positioning system : track	**E**	**E**	**E**	**E**			0 - 360°	2 (1 if available)	As installed (± 2° recommended)	0.5°	

Parameter name	Fixed wing	Rotary wing	Sail plane	Lighter than air	Piston engine	Turbine engine	Minimum Recording Range	Maximum recording interval in seconds	Minimum Recording Accuracy	Minimum Recording Resolution	Remarks
Normal acceleration	**E**	**E**	**E**	**E**			- 3 g to + 6 g (*)	0.25 (0.125 if available)	As installed (± 0.09 g excluding a datum error of ±0.05 g recommended)	0.004 g	* Acrobatic aircraft may need a wider range
Longitudinal acceleration	**E**	**E**	**E**	**E**			± 1 g (*)	0.25 (0.125 if available)	As installed (±0.015 g excluding a datum error of ±0.05 g recommended)	0.004 g	* Acrobatic aircraft may need a wider range
Lateral acceleration	**E**	**E**	**E**	**E**			± 1 g (*)	0.25 (0.125 if available)	As installed (±0.015 g excluding a datum error of ±0.05 g recommended)	0.004 g	* Acrobatic aircraft may need a wider range
External static pressure (or pressure altitude)	R	R	R	R			3.44 in-hg to 31.02 in-hg or available sensor range	1	As installed (± 0.1 in-hg or ±100 ft to ±700 ft recommended -see table II-B.2)	0.01 in-hg or 5 ft	
Outside Air Temperature (or Total Air Temperature)	R	R	R	R			-50°C to +90°C or available sensor range	2	As installed (±2°C recommended)	1°C	
Indicated air speed	R	R	R				As the installed Pilot display measuring system or available sensor range	1	As installed (±3 % recommended)	1 kt (0.5 kt recommended)	
Main rotor speed (Nr)		R					50% to 130% or available sensor range	0.5	As installed	0.3% of full range	

Parameter name	Fixed wing	Rotary wing	Sail plane	Lighter than air	Piston engine	Turbine engine	Minimum Recording Range	Maximum recording interval in seconds	Minimum Recording Accuracy	Minimum Recording Resolution	Remarks
Engine RPM					R		Full range including overspeed condition	Each engine each second	As installed	0.2% of full range	
Engine Oil Pressure					R	R	Full range	Each engine each second	As installed (5% of full range recommended)	2% of full range	
Engine Oil Temperature					R	R	Full range	Each engine each second	As installed (5% of full range recommended)	2% of full range	
Fuel flow or pressure					R	R	Full range	Each engine, each second	As installed	2% of full range	
Manifold pressure					R		Full range	Each engine, each second	As installed	0.2% of full range	
Engine thrust/power/torque Parameters required to determine propulsive thrust/power*						R	Full range	Each engine each second	As installed	0.1% of full range	* Sufficient parameters e.g. EPR/N1 or Torque/Np as appropriate to the particular engine shall be recorded to determine power in both normal and reverse thrust. A margin for possible overspeed should be provided.
Engine gas generator speed (Ng)						R	0-150%	Each engine, each second	As installed	0.2% of full range	
Free Power Turbine Speed (Nf)						R	0-150%	Each engine, each second	As installed	0.2% of full range	
Collective pitch		R					Full range	0.5	As installed	0.1% of full range	

Parameter name	Fixed wing	Rotary wing	Sail plane	Lighter than air	Piston engine	Turbine engine	Minimum Recording Range	Maximum recording interval in seconds	Minimum Recording Accuracy	Minimum Recording Resolution	Remarks
Coolant temperature					R		Full range	1	As installed (±5°C recommended)	1°C	
Fuel burner pressure or flow				R			Full range or each discrete position	1	As installed	1% of full range	
Envelope surface or inner temperature				R			As installed	As installed	As installed	1°C	
Main voltage	R	R	R	R			Full range	Each engine, each second	As installed	1 Volt	
Cylinder Head Temperature					R		Full range	each cylinder each second	As installed	2% of full range	
Flaps position	R		R				Full range or each discrete position	2	As installed	0.5°	
Primary flight control surface position	R		R				Full range	0.25	As installed	0.2% of full range	
Fuel quantity				R	R	R	Full range	4	As installed	1% of full range	
Exhaust Gas Temperature					R	R	Full range	each engine each second	As installed	2% of full range	
Emergency voltage	R	R	R	R			Full range	Each engine, each second	As installed	1 Volt	
Trim surface position	R	R	R				Full range or each discrete position	1	As installed	0.3% of full range	
Landing gear position	R	R	R				Each discrete position *	Each gear, every two seconds	As installed		* Where available, record up-and-locked and down-and-locked position
Novel/unique aircraft features	R	R	R	R	R	R	As required	As required	As required	As required	

TABLE II-B.1: PARAMETERS TO BE RECORDED

TABLE II-B.2: ALTITUDE RECORD ERROR TABLE

Standard	Equivalent Pressure Mercury		Tolerance, Feet Plus or Minus	
Altitude (feet)	MM	IN-HG	Room Temperature	Low Temperature
-1 000	787.9	31.02	100	150
-500	773.8	30.47	100	---
0	760.0	29.92	100	150
500	746.4	29.39	100	---
1 000	732.9	28.86	100	---
1 500	719.7	28.33	100	---
2 000	706.6	27.82	100	---
3 000	681.1	26.81	125	---
4 000	656.3	25.84	150	210
6 000	609.0	23.98	150	250
8 000	564.4	22.22	150	---
10 000	522.6	20.58	150	---
12 000	483.3	19.03	180	350
14 000	446.4	17.57	210	---
16 000	411.8	16.21	240	---
18 000	379.4	14.94	270	450
20 000	349.1	13.75	300	---
22 000	320.8	12.63	335	---
25 000	281.9	11.10	375	560
30 000	225.6	8.88	450	600
35 000	178.7	7.04	525	730
40 000	140.7	5.54	600	800
50 000	87.3	3.44	700	---

ANNEX II-C

MAINTENANCE PRACTICES

II-C.1 GENERAL

II-C.1.1 The maintenance tasks required to ensure the continued serviceability of the installed ADRS will depend on the extent of monitoring built into the ADRS. Appropriate inspections and functional checks, together with the intervals at which these should be performed are described in Table II-C.1.

II-C.1.2 Maintenance procedures should emphasise the need to preserve the recording following a reported incident.

II-C.2 RECORDING EVALUATION

II-C.2.1 An in-flight recording should be replayed and assessed for quality. An ADRS should be considered inoperative if there is a significant period of poor quality data, unintelligible signals or if one or more of the essential parameters is not recorded correctly.

II-C.3 PRIMARY MAINTENANCE TASKS

Table II-C.1 shows the primary maintenance tasks for the installed ADRS.

Item	Task	Maximum Interval	Interpretation
1	Operational Check	Daily or prior to each flight	Confirm serviceability using TEST function on ADRS controller or Check ‘no-fail’ indication for built in test
2	System check and replay	As agreed between operator and regulatory authority (24 months recommended)	Carry out a lossless download of the ADRS recordings immediately post-flight. Replay and evaluate the quality of the in-flight recording.

TABLE II-C.1: MAINTENANCE TASKS AND INTERVALS

PART III

AIRBORNE IMAGE RECORDING SYSTEMS

CHAPTER III-1

INTRODUCTION

III-1.1 PURPOSE AND SCOPE

III-1.1.1 General

This part defines the minimum specification to be met for an Airborne Image Recording System. This part shall be read in conjunction with Sections 1 and 2, together with Section 3 if applicable.

A combination of audio, data and cockpit image recordings will provide air safety investigators with the necessary information to better define the facts, conditions and circumstances of an occurrence, and to broaden the scope of the vitally important human factor aspects of investigations. Additionally, image recordings can capture other cockpit information that would otherwise be impractical or impossible to record.

In some instances it will be practical to use image recordings of sufficient resolution to record information that is not readily available to the ADRS or CARS (e.g. secondary displays, pilot's selections, data link messages or weather radar). However, it is always preferable to record parametric data on the ADRS rather than use an image recording, as ADRS provide a more accurate and useable recording. The use of image recordings is considered an acceptable means of compliance when it is the only method of recording parametric data that would otherwise not be economically feasible or available to the ADRS or CARS. Use of image recordings to capture data-link messages is also considered acceptable.

III-1.1.2 Description of content

This Part is divided into 6 Chapters and one Annex.

Chapter III-1 describes typical equipment applications and operational objectives. Background material and accident investigation considerations are included together with a description of the AIRS.

Chapter III-2 defines the general design specification.

Chapter III-3 defines the minimum system performance under standard test conditions.

Chapter III-4 defines the minimum system performance under environmental test conditions.

Chapter III-5 specifies tests and procedures for determining compliance with the performance requirements.

Chapter III-6 defines the installed equipment performance requirements including ground tests and flight tests.

The Annex provides additional guidance on maintenance practices.

III-1.2 APPLICATION

III-1.2.1 Airborne Image Recording System

Compliance with this Part will ensure that the AIRS will perform its intended function under the conditions encountered in aircraft operations.

III-1.3 DESCRIPTION OF THE SYSTEM

III-1.3.1 Equipment

The AIRS may include the following equipment as appropriate to the aircraft:

a Cockpit equipment, including controls for bulk erase functions, failure indication and single or multiple cameras/image sources,

b Image communication network,

c A robust recorder in which it is recommended that the recording be synchronised with the other airborne recording systems and UTC,

d Interface equipment to provide communication between the elements of the system.

III-1.3.2 Classes of Recording Systems

For the purposes of this MOPS, AIRS are classified by "Class" as follows.

AIRS Class	AIRS Purpose
A	Able to provide a general image of the cockpit including instruments, external view, movements etc. Refer to III-1.3.3.c.i.
B	Records data-link message display.
C	As a means for recording flight data where it is not practical or prohibitively expensive to record otherwise. Refer to III-1.3.3.c.ii.
D	As a means of capturing Head Up Displays.
E	As a means of capturing other camera images presented to the pilots. For example – To capture cargo or cabin views, as selected in the cockpit, which may be achieved by directly recording the images presented to the pilots, or indirectly using a camera.
F	External view For example – to capture forward view or aircraft parts such as landing gear.

III-1.3.3 Operational Considerations

a Objectives

Each AIRS should be installed so as to provide, with reference to a timescale, simultaneous recordings, on separate channels, of one or more areas of coverage.

b Start and Termination of Recording

Recorder operation shall be as defined in paragraph 2-1.5.

c Areas of coverage

The following coverage areas are not necessarily related to the number of cameras required to obtain the information. It may be that one camera can satisfy several requirements or that several cameras are necessary to satisfy one requirement.

Each aircraft may need to be assessed on an individual basis to identify the need for an appropriate number of dedicated image sensors to sufficiently capture the information described in sub-paragraphs i and ii below.

A coverage area refers to the information required to be captured.

i. General Cockpit Area

Coverage areas: All pilot's stations work areas including instruments and controls.

Purpose: To determine the following:

- Ambient conditions in the cockpit (smoke, fire, lighting, etc.);
- General pilot's activities such as use of checklists, charts, etc, and health and well-being of pilots;
- Non-verbal communications (hand signals, pointing, etc.);
- Cockpit selections within pilot's reach while seated at duty station (switch/throttle/flight controls, etc).

Resolution: Sufficient to determine general pilot's activities and ambient conditions;

Frame Recording Rate: Sufficient to determine significant pilot's actions.

Colour: Required

ii. Instruments and Control Panels:

Coverage Area: Forward Instrument Panel

Purpose: To determine the following:

- Status of instrument displays and display modes (blank screen, partial display, automatic display mode changes, etc.);

Resolution: Sufficient to:

- Determine instrument display status and operational mode of the displays
- Determine parameter values whose recording requirements can only be met by image recording.

Frame Recording Rate: As specified in paragraph III-2.1.8

Colour: Required

iii. Pilot's Privacy Issues

Misuse and privacy issues with respect to recorded voices, images and to some extent data, remain of significant concern to the aviation community. When taken out of context, images of the cockpit have the potential to mislead inexperienced people by virtue of their readily understandable format. They will also tend to have a high media appeal for sensationalist purposes and higher potential to be viewed out of context. Privacy issues generally increase in sensitivity when information contains personal and/or emotional elements. This is the primary reason why audio recordings are considered privileged by most investigation authorities and international standards. Image recordings should be treated with the same, or higher, level of sensitivity.

iv. Use of AIRS

It is the intent of investigators to obtain information with respect to pilots interaction, the human/machine interface and information that is otherwise impractical to record. It is therefore not necessary to record the total image of the pilots.

While accident investigators recognise and share the privacy and misuse concerns, the need to record the image of the general cockpit environment is nonetheless considered fundamental.

Use of audio and image recordings for reasons other than aviation safety, can do a disservice to the community as well as harm individuals, and can be detrimental to an investigation and the parties involved.

In order to prevent unauthorised access to image recordings, gain further acceptance by the aviation community, and minimise the potential for misuse, it is required that:

a Following an accident or reportable incident, recorded images may be used only for investigation purposes and shall not be publicly disclosed. To ensure that the recording is not used for purposes other than investigation, the investigative authority shall retain custody of the recording. It is recommended that the manufacturer of the image recording system insert a similar warning in his system documentation,

b Provisions shall be made for a pilot operated post flight bulk erase,

c Playback of image recordings by unauthorised persons shall be inhibited through the use of suitable protection mechanisms (refer to paragraph III-2.1.7),

d Use of image data for training and maintenance purposes is permitted.

CHAPTER III-2

AIRS DESIGN SPECIFICATION

III-2.1 EQUIPMENT DESIGN SPECIFICATION

III-2.1.1 General

This chapter is applicable to the functions of a flight recording system designed to receive, process, record and preserve image information in accordance with the requirements of this MOPS. These functions shall be performed reliably even under adverse operating conditions including events leading to an accident.

The operation of AIRS controls intended for use during flight, in all possible positions, combinations and sequences, shall not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.

This section shall be read in conjunction with Section 2, which defines the requirements that are generic to all flight recording systems.

III-2.1.2 Recording Techniques

a The AIRS shall use a digital method of recording and storing the data in a robust memory module.

b The recorded information shall be able to be exported to an industry standard digital format without loss of quality, or timing correlation irrespective of the recording format.

c Image compression techniques may be used to minimise the amount of recording medium dedicated to image recording.

III-2.1.3 Recording Capacity

The AIRS shall be capable of retaining the data recorded during at least the last 2 hours of its operation.

III-2.1.4 Means of Access to Recorded Information

The means for accessing the recorded information shall not erase, re-write or alter the recording.

The means of replay, which will be provided by the manufacturer, shall produce image data in an unencrypted, industry standard format. If the data has been encrypted the manufacturer shall provide the information required to decrypt the data as part of the AIRS maintenance manual.

NOTE: *It is not required for the airs to continue to record images whilst the recorded data is retrieved.*

III-2.1.5 Recording Delay

The delay between the acquisition of the image at the image sensor, and the time the data is stored in the robust medium, shall be minimised, and shall not exceed 3 seconds.

III-2.1.6 Image Compression

Image compression techniques may be used to minimise the amount of recording medium dedicated to image recording. The loss of one image (frame or equivalent) shall not result in the loss of more than one second of images.

It shall be possible to reconstruct the images from the information stored in the robust memory module. Under normal replay conditions the images shall be available both as a real time flow of images, and as one image at a time.

The image compression techniques may generate limited artefacts or loss of details. These shall not preclude the overall system from meeting the requirements of paragraph III-1.3.3.

III-2.1.7 Image Security/Encryption

To address the privacy and security concerns in paragraph III-1.3.3iii the provision of a dual password or encryption key protection capability for image playback systems such that both passwords are required to playback a recording could be utilized. Official investigation authorities will have access to specialised playback capability that does not require the use of these passwords/encryption keys.

NOTE: *It is envisaged that the passwords will be delegated to the operator and its pilot representative.*

III-2.1.8 Minimum Required Frame Recording Rates

Images from each sensor(s), as installed, shall be updated with the following rates as a minimum:

AIRS Class	Description	Minimum Frame Recording Rate	
		Recording Period Most Recent 30 mins	*Recording Period 30 mins - 2 hour*
A	General Cockpit View	4 per second	1 per second
B	CPDLC Message Display	1 per second	1 per 2 seconds
C	Cockpit Displays	4 per second	1 per second
D	Head Up Display	1 per second	1 per 2 seconds
E	Other Camera Images when presented to the pilots	1 per second, or the rate provided to the pilots, whichever is lower	1 per 2 seconds, or the rate provided to the pilots, whichever is lower
F	External view	4 per second	1 per second

III-2.1.9 Privacy of Recorded Images

To respect pilot privacy, cockpit area views shall be designed as far as practical to exclude the head and shoulders of pilots whilst seated in their normal operating positions.

III-2.1.10 Bulk Erase

For Class A AIRS, provision should be made for a pilot-operated post-flight bulk erase function. Where a Class C AIRS is used instead of an ADRS to capture parametric data from instrument displays (refer to paragraph III-1.1.1), a facility to bulk erase that captured parametric data shall not be provided.

After use of a bulk erase function, the recording shall be modified so that it cannot be retrieved using any normal replay (refer to note 2 below) or copying techniques.

An acceptable means of compliance would be for a bulk erase function to delete that information needed to access the memory by the normal replay procedure.

The installation of a bulk erase function should be designed to prevent unintentional operation during flight or crash impact.

***NOTE 1*:** *In the event of bulk erasure, non-normal replay or copying techniques may be used by the accident investigation authority to retrieve data, for the purposes of conducting an official investigation.*

***NOTE 2*:** *Normal replay is data retrieval at the equipment level as used in the laboratories of aircraft constructors and modifiers to support certification of recording system installations.*

***NOTE 3*:** *Non-normal replay is data retrieval from the recording medium media using special techniques available to the recording system manufacturers and accident investigation authorities.*

NOTE 4: *It is understood that military organisations may use commercial recorders. In this case, they may have unique requirements outside the scope of this MOPS.*

III-2.1.11 Maintenance Access

The installed system shall allow a loopback real time monitor function for test purposes and alignment.

NOTE: *The current image(s) from the system may be displayed on command. This should not allow the display of recorded images.*

III-2.2 CAMERA SPECIFICATIONS

III-2.2.1 General

There shall be no requirements for pilot intervention during normal operation.

III-2.2.2 Beating Effects

For those AIRS where data is to be retrieved from electronic instrument displays, beating effects should be minimised.

III-2.2.3 Optical Characteristics

III-2.2.3.1 Spatial Resolution

Spatial resolution of the images shall be verified by differentiation of resolution lines presented for the appropriate information class. For Class A, B and C images, the resolution as shown in TABLE III-3.1 should be used.

III-2.2.3.2 Depth of field

Depth of field shall be sufficient for the Class of image recording as shown in TABLE III-3.1.

NOTE: *For a Class B or C AIRS, the required depth of field need only encompass the instrument panel (furthest instruments to nearest instruments) whereas for a Class A AIRS, the required depth of field should be as large as possible to accurately focus all movement in the cockpit.*

III-2.2.3.3 Field of View

Field of view shall be sufficient for the class of AIRS as shown in TABLE III-3.1.

III-2.2.3.4 Contrast

The level of contrast shall be adequate to differentiate between the lines presented on the Test Chart as appropriate for the class of AIRS as shown in TABLE III-3.1.

III-2.2.3.5 Distortion

Distortion of the Image shall be minimised in order to allow for differentiation between the lines presented on the Test Chart as appropriate for the Class of image recording as shown in TABLE III-3.1.

III-2.2.3.6 Digital Artefacts

The level of artefacts introduced by the digitisation and compression systems shall not compromise the required resolution of the AIRS specified in TABLE III-3.1.

III-2.2.4 Spectral Bandwidth

The objective of the Class A, general cockpit view, is to record the cockpit environment as experienced by or presented to the pilots. The wavelengths of light sensed should be optimised to the spectral sensitivity of the human eye as closely as practicable.

NOTE: *The eye generally has a spectral wavelength sensitivity range from 410 nm to 710 nm.*

For Class B, C, D, E and F installations the spectral bandwidth should be optimised to capture the intended information.

III-2.2.5 Lighting and Sensitivity

The image sensor shall not require supplemental lighting during normal operation.

The AIRS shall be capable of operating in lighting conditions from 86 000 lux (full sun) to an illumination of 1.0 lux, by automatic means, and for Class B and C AIRS shall be capable of resolving data from instruments with a luminance of 1.71 +/- 0.85 nits.

III-2.2.6 Dynamic Range

The image sensor shall accommodate a dynamic range of lighting of at least 10:1 between the brightest and darkest elements in a single image while providing the resolution, contrast, and depth of colour performance specified herein.

III-2.2.7 Depth of Colour

Where a colour image is required, the depth of colour shall be no less than 256 colours, distributed across the visual bandwidth.

CHAPTER III-3

MINIMUM PERFORMANCE SPECIFICATIONS UNDER STANDARD TEST CONDITIONS

III-3.1 INTRODUCTION

This chapter specifies the minimum performance specification of the equipment and the levels to be demonstrated under standard test conditions.

III-3.1.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F "Environmental Conditions and Test Procedures for Airborne Equipment" paragraph 3.4 as:

a Temperature : +15 to +35°C

b Relative Humidity : Not greater than 85%

c Ambient Pressure : 84 to 107 kPa

d Lighting Level : Between 100 and 1 000 lux

In addition to the above the electrical power supply shall be within the limits specified as Normal in Section 16 of ED-14F/DO-160F or subsequent issue.

In the case of equipment designed for operation from an AC power source of variable frequency, unless otherwise specified, tests should be performed at representative input power frequencies with the input frequency adjusted to within 5% of a selected frequency.

III-3.2 RECORDING SYSTEM PERFORMANCE LEVELS

The equipment shall be tested to show compliance with the following minimum performance levels.

***NOTE*:** *Where these paragraphs state requirements regarding the information in the memory it should be interpreted as that obtained by numerical analysis of the recorded audio data or as that observed at the output of suitable playback equipment.*

III-3.2.1 Recovered Image Quality

The recovered image shall conform to TABLE III-3.1.

III-3.2.2 Start-up and Effects of Power Interruptions

Following a system electrical power interruption, the characteristics of the AIRS (including any networks, busses etc) shall be such that:

a Following initial application of power to the AIRS and any start logic is satisfied, the recording system shall commence and continue to store information, in accordance with the requirements of this MOPS, within 120 seconds.

b All information available at the start of an interruption together with that available in the following 10 ms shall be recorded in the robust memory module.

c After 5 seconds at a normal power level, interruptions with duration of less than 10 ms shall have no effect on the AIRS, Class A, B, C and D image sensors and AIRS control panel (including any interconnecting networks, busses etc). The initial 5 second period allows time to recharge the energy storage.

NOTE 1: *Systems should be designed to minimize the start up time and should start recording as soon as data is available to the recording system. Recording should not wait until all BITE and sub-system start-up functions are completed: for example, audio and image information may be available before other parametric data.*

NOTE 2: *During power interruptions of less than 2 seconds some sensors may not provide valid data to the recorder, but the recording system shall continue to operate.*

AIRS Class (per paragraph III-1.3.2)	Resolution	Field of View	Sensitivity	Contrast / Grey Scale	Distortion & Artefacts
A	Sufficient to distinguish 5mm resolution bars as per test chart at the forward instrument panel	Forward view of the cockpit	Adequate to discern pilot movement at 1 lux	256 colours	Meet required resolution
B	It shall be possible to visually differentiate between 4mm display panel numeric (for example “5” and “6”) on an image.	Face of display	Distinguish between “5” and “6” at 1.7 nits	256 colours	Meet required resolution
C	It shall be possible to visually differentiate between 4mm display panel numeric (for example “5” and “6”) on an image.	Full width of forward instrument panel	Distinguish between “5” and “6” at 1.7nits`	256 colours	Meet required resolution
D	As provided by system	As provided by system	As provided by system	As provided by system	Meet required resolution
E	As provided by system	As provided by system	As provided by system	As provided by system	Meet required resolution
F	As provided by system	As provided by system	As provided by system	As provided by system	Meet required resolution

TABLE III-3.1: IMAGE QUALITY CHARACTERISTICS

CHAPTER III-4

MINIMUM PERFORMANCE SPECIFICATIONS UNDER ENVIRONMENTAL TEST CONDITIONS

III-4.1 INTRODUCTION

Chapter 2-3 defines the environmental tests to be performed on the recording system.

Compliance with the applicable performance requirements of this part for the AIRS shall be demonstrated as shown in TABLE III-4.1.

III-4.2 EXCEPTIONS TO GENERAL REQUIREMENTS

There are no exceptions to the general requirements defined in Chapter III-3 for AIRS.

ENVIRONMENT	Test Reference ED-14F/DO-160F section	MOPS PARAGRAPH NUMBER					
		2-1.5 Recorder operation	III-3.2.1 Resolution	III-3.2.1 Sensitivity	III-3.2.1 Contrast / Grey Scale	III-3.2.1 Distortion / Artefacts	III-2.1.8 Update Rate
Temperature	4	R	R	R	R	R	R
Altitude	4	R	R	R			
Temp Variation	5	R	R	R			
Humidity	6	R	R			R	R
Shock	7	R					R
Vibration	8	R					R
Magnetic Effect	15	R					
Voltage Spike	16	R	R			R	
Power Input	17	R	R			R	
AF Susceptibility	18	R	R			R	
Induced Susceptibility	19	R	R			R	
RF Susceptibility	20	R	R			R	
RF emission	21	R					
ESD	25	R					

Key Blank = Manufacturer's Discretion R = Test Required

TABLE III-4.1: ENVIRONMENTAL TEST MATRIX FOR AIRS

CHAPTER III-5

TEST PROCEDURES

III-5.1 INTRODUCTION

This chapter specifies the standard test procedures for demonstrating compliance with Chapter III-2 and Chapter III-3. Although specific test procedures are cited, it is recognised that they will not apply in all cases and that other methods may be preferred or required. Alternative methods may be used if the manufacturer can show that they provide equivalent certification data.

Where a test procedure is not specified for a particular performance parameter, the manufacturer may show compliance either by analysis or by devising a test appropriate to the equipment design. All test measurements shall be traceable to a recognized calibration standard.

III-5.1.1 Adjustment of Equipment

The equipment under test shall be properly aligned and adjusted in accordance with the manufacturer's recommendations.

III-5.1.2 Test Instrument Precautions

Precautions shall be taken to prevent the introduction of errors resulting from impedance mismatch and the improper connection of test instruments to the equipment under test.

III-5.1.3 Test Conditions

Unless specified as part of environmental testing, all tests shall be performed under the conditions specified in paragraph III-3.1.

III-5.1.4 Connected Loads

Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance values for which it is designed.

III-5.1.5 Warm-up Period

Unless otherwise specified, all tests shall be performed after a warm-up (stabilisation) period of not less than 5 minutes and not more than 15 minutes.

III-5.1.6 Recording of Test Results

Except where tests are ”Pass / Fail” in character (e.g. the determination of whether or not mechanical devices function correctly), the actual numerical values obtained for each of the parameters tested shall be recorded in a qualification test report.

III-5.1.7 Recovered Image Quality

The quality of the recovered image shall be established and shall not be less than that corresponding to the values of “quality index pattern” as stated below.

The overall system quality can be assessed by imaging a reference test pattern. This test pattern shall have the following attributes which are met by the test chart shown in *FIGURE III-5.1*:

- Horizontal lines with separation ranging from 5 mm to 1 mm spacing.
- Vertical lines with separation ranging from 5 mm to 1 mm spacing.
- Colour blocks with 8 typical cockpit colours (red, green, blue, magenta, cyan, yellow, black and white).
- Text (compatible with class B and C image)
- Industry standard preferred.

This pattern, which will be 0.3 m x 0.225 m, should be placed in the 4 corners and the centre of the image area which typically measures 2 m (horizontal) by 1.6 m (vertical) minimum, as shown in FIGURE III-5.2. Alternative dimensions may be used, but should be representative of the dimensions and format of the cockpit in which the equipment is to be installed. The background of the image area shall be patterned to represent a typical cockpit. It shall be possible to distinguish the lines at the required separation level after imaging and reproducing the image with the system under test under standard lighting conditions (100 – 1 000 lux). Other lighting conditions will be verified in separate tests.

NOTE: FIGURE III-5.1 *requires full colour reproduction, which is not possible within this document. The chart is not to scale, A chart with correct colours, scaling and resolution may be obtained from EUROCAE.*

III-5.1.8 Start of Recording

The equipment shall be switched on, and the time until the first image is successfully recorded shall be noted. This shall conform to the timing requirements given in paragraph III-3.2.2.

III-5.1.9 Recording Frame Rate

The equipment shall be set to operate, viewing a scene representative of an aircraft cockpit. The equipment shall be allowed to stabilise for a period of 5 minutes.

The equipment shall then be operated over a period of one minute, and the number of picture frames recorded shall be recorded. A frame rate per second shall be calculated, and conformity with the required update rate for the AIRS shall be established.

Required recording frame rates shall be as defined in “Most Recent 30 min” column of paragraph III-2.1.8.

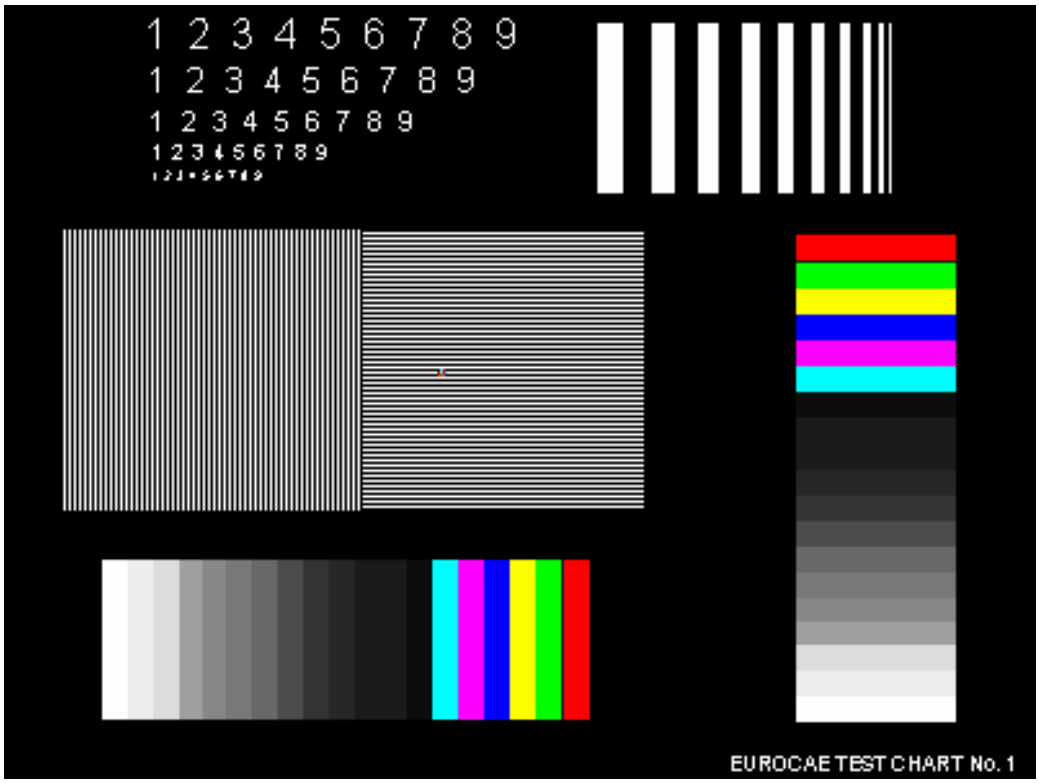


FIGURE III-5.1: EXAMPLE QUALITY INDEX PATTERN

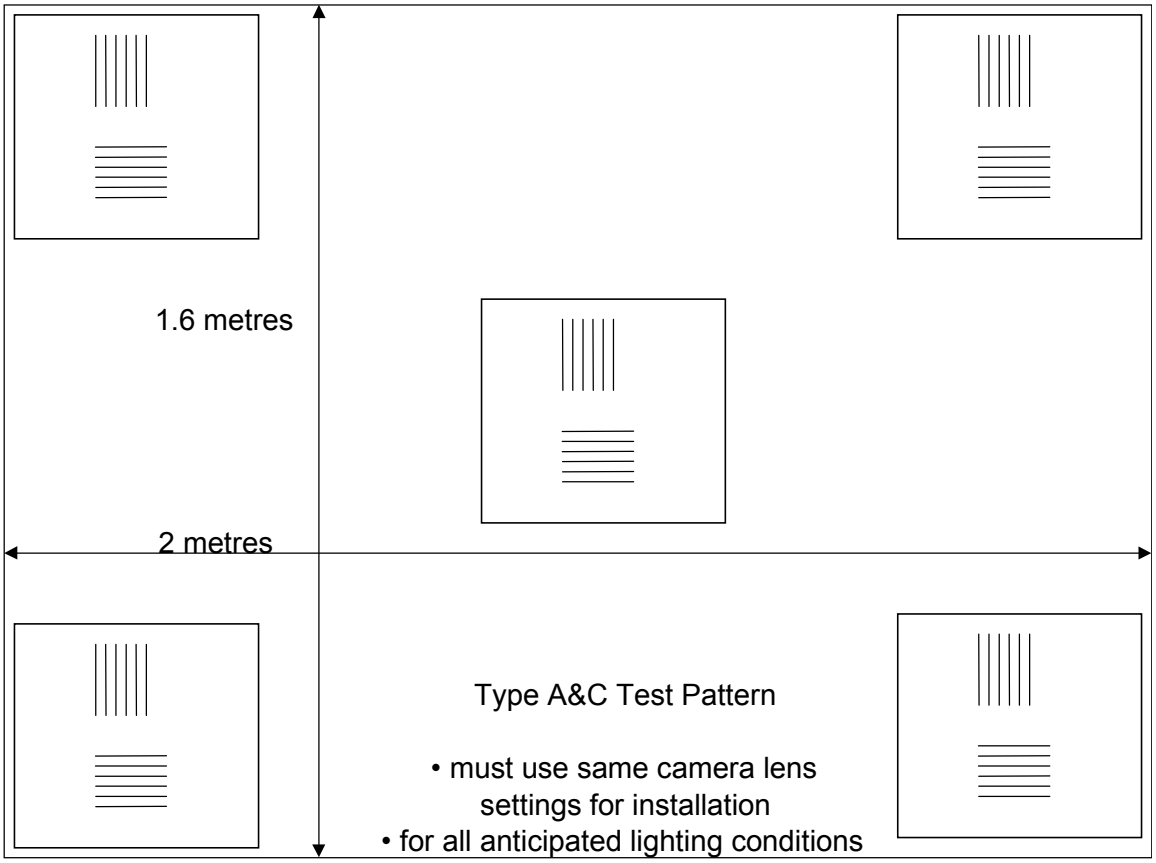


FIGURE III-5.2: TYPICAL ARRANGEMENT OF TEST PATTERN

CHAPTER III-6

EQUIPMENT INSTALLATION AND INSTALLED PERFORMANCE

III-6.1 INTRODUCTION

This chapter specifies installation characteristics and performance with procedures for verifying that performance when the equipment is installed in an aircraft.

Installed performance criteria are generally the same as those contained in Chapter III-3, which were verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be confirmed after installation.

III-6.2 EQUIPMENT INSTALLATION

III-6.2.1 Accessibility

a Maintenance provisions for equipment adjustments should not be readily accessible to the pilots.

b Bulk erase control (if installed) shall be available in the cockpit.

III-6.2.2 Aircraft Environment

Equipment shall be compatible with the environmental conditions present in the specific location in the aircraft where the equipment is installed.

Operation of the equipment shall not be affected by aircraft manoeuvring or changes in attitude encountered in normal flight operations. Operation of the equipment should not be affected by those extreme conditions likely to, be encountered during an accident sequence e.g. stall buffet, violent and extreme manoeuvres, however under these conditions picture quality may be degraded.

Based on the expected displacement of the camera relative to the scene being viewed, it is recommended that the camera is mounted sufficiently rigid to avoid resonances.

III-6.2.3 Interference Effects

The installed equipment shall not:

a be the source of harmful conducted or radiated interference, nor

b be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

NOTE: *Electromagnetic compatibility problems noted after installation of the equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installer will be responsible for resolving any incompatibility between the equipment and previously installed equipment.*

III-6.2.4 Bulk Erase Control

The installation of a bulk erase control should be designed to prevent activation during flight and to minimize any inadvertent operation during a crash impact.

III-6.2.5 Quality of Recovered Image

For each newly installed system, the quality of the recovered image shall be established by analysis of data recorded on the ground and in flight.

III-6.2.6 Maintenance

An analysis shall be performed by the equipment installer to identify those aspects of the installation where the serviceability could be degraded and remain undetected. The maintenance tasks to be performed shall take account of this analysis by requiring appropriate functional and maintenance checks at suitable intervals.

III-6.3 GROUND TEST PROCEDURES

III-6.3.1 Equipment Function

Vary all controls of the equipment through their full range to determine that the equipment is operating according to the manufacturer's instructions and that each control performs its intended function.

III-6.3.2 Interference Effects

With the equipment energised, individually operate each of the other electrically operated aircraft equipment and systems to determine that no significant levels of conducted or radiated interference exist.

Operate communication and navigation equipment on the low, high and at least one mid-band frequency.

Identify systems or modes of operation that should be evaluated during flight.

III-6.3.3 Power Supply Fluctuations and Protection

Verify equipment operation from available aircraft power sources, including normal generator switching.

III-6.4 FLIGHT TEST PROCEDURES

III-6.4.1 General

This section provides guidance for flight testing installations on aeroplanes and helicopters. The guidance may need to be adapted to suit the particular installation being tested.

Each newly installed AIRS will need to be flight tested, and the recording so obtained shall be evaluated to show adequate recording quality during normal regimes of flight including taxiing, takeoff, cruise, approach and landing.

For helicopters, hover and autorotation should be included.

Since the duration of the recording may be limited, the flight test should be carefully planned. The AIRS circuit breaker can be tripped between each test phase and at the end of the landing run if the flight time is likely to exceed the recording duration limit.

The replay and evaluation will need to be performed after the flight test. If mandated by the certifying authority, verification of the flight test recording shall be performed by an approved readout and replay centre.

ANNEX III-A

MAINTENANCE PRACTICES

III-A.1 GENERAL

III-A.1.1 The maintenance tasks required to ensure the continued serviceability of the installed AIRS will depend on the extent of monitoring built into the AIRS. Appropriate inspections and functional checks, together with the intervals at which these should be performed are described in Table III-A.1.

III-A.1.2 Maintenance procedures should emphasise the need to preserve the recording following a reported incident.

III-A.2 RECORDING EVALUATION

III-A.2.1 An in-flight recording should be replayed and assessed for quality.

III-A.3 PRIMARY MAINTENANCE TASKS

Table III-A.1 shows the primary maintenance tasks for the installed AIRS.

Item	Task	Maximum Interval	Interpretation
1	Operational Check	Daily or prior to each flight	Confirm serviceability using TEST function on AIRS controller or Check 'no-fail' indication for built in test
2	System check and replay	As agreed between operator and regulatory authority (24 months recommended)	Carry out a lossless download of the AIRS recordings immediately post-flight. Replay and evaluate the quality of the in-flight recording.

TABLE III-A.1: MAINTENANCE TASKS AND INTERVALS

PART IV

DATA-LINK RECORDING SYSTEMS

CHAPTER IV-1

INTRODUCTION

IV-1.1 PURPOSE AND SCOPE

IV-1.1.1 General

This part defines the minimum specification to be met for a Data-Link Recording System. This part shall be read in conjunction with Sections 1 and 2, together with Section 3 if applicable.

IV-1.1.2 Description of content

This part is divided into six Chapters and two Annexes.

Chapter IV-1 describes typical equipment applications and operational objectives. Background material and accident investigation considerations are included together with a description of the DLRS.

Chapter IV-2 defines the general design specification.

Chapter IV-3 defines the minimum system performance under standard test conditions.

Chapter IV-4 defines the minimum system performance under environmental test conditions.

Chapter IV-5 specifies tests and procedures for determining compliance with the performance requirements.

Chapter IV-6 defines the installed equipment performance requirements including ground tests and flight tests.

The Annexes provide details of the parameters to be recorded and give additional guidance on maintenance practices.

IV-1.2 APPLICATION

IV-1.2.1 Data-Link Recording System

Compliance with this Part will ensure that the DLRS will perform its intended function under the conditions encountered in aircraft operations.

IV-1.3 DESCRIPTION OF THE SYSTEM

IV-1.3.1 Equipment

The DLRS may include the following equipments as appropriate to the aircraft:

a. A robust recorder in which it is recommended that the recording be synchronised with the other airborne recording systems and UTC,

b. Digital interface equipment suitable for converting a data-link message into a format which is to be recorded, and

c. Digital data busses or networks providing communications between elements of the system.

IV-1.3.2 Operational Considerations

a. Objectives

Each DLRS should be installed so as to provide, with reference to a timescale, a recording of data-link messages to and from an aircraft.

b. Start and Termination of Recording

Recorder operation shall be as defined in paragraph 2-1.5.

CHAPTER IV-2

DLRS DESIGN SPECIFICATION

IV-2.1 EQUIPMENT DESIGN SPECIFICATION

IV-2.1.1 General

This section is applicable to the functions of a flight recording system designed to receive, process, record and preserve data-link information transmitted to and from the aircraft in accordance with the requirements of this MOPS. These functions shall be performed reliably even under adverse operating conditions including events leading to an accident.

This section shall be read in conjunction with Section 2, which defines the requirements that are generic to all flight recording systems.

The requirements for digital communications that may be recorded both on board the aircraft and on the ground are summarised as follows. For complete text of the overall systems requirements and message types to be recorded refer to Minimum Aviation System Performance Specification for CNS/ATM Recorder Systems (ED-93):

a It is desirable that all communications to and from the pilots are recorded on the aircraft in order to develop a thorough understanding of the working environment of the cockpit. This is of fundamental importance to accident investigation.

b In the same way that traditional audio recording has enabled investigators to determine if radio communications systems were overall functioning as required, the airborne recording of digital communications will help to determine the end-to-end functioning of the data-link communication system.

c Increased reliance will be placed on digital messaging to ensure safe operation in an environment where separations will be significantly reduced and profiles flown will be assumed to be much more precise. Much of this information may not involve the pilots or controller and messages may be addressed directly to and from the aircraft's systems. The recording of such information will prove valuable.

d Ground based recording will involve many stations and locations around the world. An effective means of ensuring that the information is readily available to an accident investigation is to record as much of it, as practical on board the aircraft.

e Recording on the ground is required in order to correlate the transmitted and received messages and to investigate periods beyond the duration of the airborne recording. Part of this reason is to be able to understand the role of air traffic control in the occurrence, and to be able to understand the interactions between ground stations, other aircraft, and other agencies.

f To meet the operational goals, there are two main issues each of which require consideration in terms of both airborne and ground recording:

   i. Recording of digital communications to and from the pilots. This includes those messages that would have traditionally been passed by voice means.

   ii. Other data-link messages that are transmitted to and from the aircraft for the purposes of weather information, navigation and surveillance (For example differential GPS requiring position correction), and advanced TCAS that may require communication from aircraft to aircraft.

IV-2.1.2 Recording Techniques

a The DLRS shall use a digital method of recording and storing the data in a robust memory module.

b Each message shall be recorded in a format that is easily identified and can be decoded with reference to the documents specified in 2-1.3.4.d.

c Data compression shall not be used.

IV-2.1.3 Recording Capacity

The recording system shall have adequate capacity to record all required data-link messages during the most recent time period of at least 2 hours.

***NOTE 1*:** *Future technology may require alternate bus transfer speeds and larger recording medium capacity. This should be taken into account in the design of the recording system.*

***NOTE 2*:** *As the data-link message recording is an event type recording (opposed to sequence method as is the case for the audio recording system), there is no fixed relationship between the recording medium capacity and the duration of the recording. However in some circumstances, the data-link message traffic may exceed the limit defined, and consequently the recording duration may be insufficient regarding the recording medium size defined.*

The recording system shall, as a minimum, provide sufficient capacity to store 5 standard messages per minute and each followed by an acknowledgement message of 28 characters (in addition to any protocol overhead as required to meet this specification), for a duration of at least 2 hours.

***NOTE 3*:** *This requirement is derived from a perceived maximum of current CPDLC traffic and message sizes. It is based on the assumption that 60 percent of the recording capacity will be used for CPDLC messages, and the remaining 40 percent for other types of messages.*

***NOTE 4*:** *Today's definition of data-link architectures do not provide enough information on the amount of anticipated or typical data flow and as such it is suggested that sufficient reserve shall be provided for system growth.*

***NOTE 5*:** *In order to minimise recording medium utilisation and to optimise recording medium capacity, data-link messages may be recorded on an interrupt basis, i.e. as the message occurs.*

IV-2.1.4 Means of access to Recorded Information

The means for accessing the recorded information shall:

a not erase, re-write or alter the recording,

b utilise a standard computer interface for lossless retrieval of all data,

c not require the removal of the robust memory module from its location in the aircraft and,

d allow accident investigation authorities unrestricted access to the data.

NOTE: *it is not required for the DLRS to continue to record information whilst the recorded data is retrieved.*

IV-2.1.5 Recording Delay

The delay in recording the data, from the time that it is presented at the input of the recording system to the time this data is stored in the robust medium, should be minimised.

For a standard message (as defined in paragraph IV-3.2.2) the delay in recording the data, from the time of reception of the complete message at the recording device to the time of recording in the robust memory module, shall not exceed 1 second.

***NOTE 1*:** *For a message with a larger payload than the standard message or a burst of messages the delay may exceed the limit of 1 second.*

NOTE 2: *It is important to preserve all available data. For this reason, any delay should be minimised. Where buffer devices are used, it is strongly recommended that non-volatile devices are used and that they are located within the robust memory module.*

For a standard message (as defined in paragraph IV-3.2.2), the delay between the message being recognized as data to be recorded and the last bit being presented at the recording device shall not exceed 2 seconds.

In any case, for a message of any length, the delay between the message being recognized as data to be recorded and the first bit being presented at the recording device shall not exceed 2 seconds.

NOTE 3: *System delays attributable to the installed data-link communication system are outside this scope of this chapter and are not addressed.*

IV-2.1.6 Data to Be Recorded

IV-2.1.6.1 Data-link applications and services to record

If the aircraft flight path is authorized/controlled directly or indirectly by data-link messages, then all data-link messages, both up-links (to the aircraft) and down-links (from the aircraft), the time they are displayed to the pilots, and their data-link response shall be recorded on the aircraft in order to determine an accurate sequence of events for the aircraft and cockpit operation.

AOC/AAC data-link services, navigation and surveillance parameters should be recorded if data-link message transfer is a feature of the system architecture – refer to Annex IV-A for message type details required to be recorded.

Message recording and associated timing shall apply to the recording requirements of:

a Pilots Communication as defined in ED-93 paragraph 2.3.2.1,

b Navigation as defined in ED-93 paragraph 2.3.2.3,

c Surveillance as defined in ED-93 paragraph 2.3.2.5.

***NOTE**:* *In order to minimise recording medium utilisation, data-link messages may be recorded on an interrupt basis, i.e. as the message occurs.*

The recording of digital messages may be made in one or more airborne recording systems.

The data-link message shall be recorded on the aircraft, whether generated automatically or manually, and shall be independent of the media transmission method (VHF, Satcom, HF, Mode-S or other).

IV-2.1.6.2 Content of recordings

Sufficient information shall be recorded to enable the following to be determined:

a The content of all messages generated and received by the pilots,

b The message priority (if any),

c The number of messages in any available queue,

d The display status of each message.

NOTE 1: *Clarification of "Message priority": Being able to determine message priority means - if a message has an associated priority that may have an effect upon the order of or method of its display or transmission, then the existence of such a priority should be determinable from the recorded information.*

NOTE 2: *Clarification of "Available queues": Being able to determine the number of messages in available queues means – as far as practical given by the architecture of the system the recorded information should be sufficient to determine at any given time, how many messages may have been received at the aircraft, but not displayed to the pilots. Conversely, it should be determinable how many messages the pilots have generated which have not yet been sent to the ground.*

NOTE 3: *Clarification of "Display Status": The recording of message display status means, as far as practical, given the architecture of the system, information concerning the state of pilots selection of the messages should be recorded. Current states may include new arrival, open, acceptance, rejection of messages, etc.*

IV-2.1.6.3 Time Stamp

It shall be possible to determine time information associated with each data-link message, with a minimum resolution of 1 second. The time information shall include hours/minutes/seconds/day/month and should include year, if available.

NOTE 1: *The reason for the inclusion of date within the timestamp is that, since a data-link message may be recorded on interrupt basis, there may be information from more than a single 24-hour period within the recording system and the date will provide information to determine which is most recent.*

The following timing information associated with the digital messages shall, as far as practical given the architecture of the system, be capable of being determined from the airborne-based recordings:

a The time each message was generated (i.e. when "send" was selected),

b The time any message was available to be displayed by the pilots,

c The time each message was actually displayed or recalled from a queue,

d The time of each status change.

NOTE 2: *Clarification of "Time stamp": The recording of time stamps means – the recorded information associated with each message should be sufficient to determine the time the message was recorded. This can be accomplished either by recording an explicit time identifier with each message or by recording in such a manner that the relative time can be referenced to a timeline with an absolute time basis.*

NOTE 3: *Clarification of "Status change": The recording of message status change means – as far as practical given the architecture of the system, information concerning the pilots interaction with the messages should be recorded. Interactions include acknowledgement of messages, recall of messages, WILCO of messages, etc.*

IV-2.1.7 Data Burst Throughput

The recording system should be capable of processing and recording a high speed burst of digital data at the maximum rate of the interface employed in the digital communication system design which shall have no adverse effect on the performance of the recording system. (Refer to paragraph IV-3.2.3)

IV-2.1.8 Databus Selection

The databus interface chosen for the recording system shall, as a minimum, support the amount and frequency of digital message traffic required to be recorded in accordance with design requirements of this MOPS.

IV-2.1.9 Recording Format

Each message shall be recorded in a format that is easily identified and can be decoded with reference to the documents specified in 2-1.3.4.d.

IV-2.1.10 Erasure of Recorded Data

a Except for the overwriting of the oldest data by new information, no means for the erasure of the recorded data shall be provided in the recording system.

NOTE: *It is understood that military organisations may use commercial recorders. In this case, they may have additional security requirements that exempt the recording system from this requirement. Arrangements should be made with the appropriate certification authority in regard to such exemptions.*

b It is recommended that appropriate procedures are used to avoid the over-writing of data during aircraft maintenance following a reportable incident or accident.

IV-2.1.11 Quality and Reliability of Recording

a For each newly installed system, the performance of the system and quality of recorded data shall be established by analysis of data recorded on the ground and in flight.

b It is recommended that the relevant accident investigation authority should be invited by the certification authority to participate in the assessment of new systems and the quality of the recorded data particularly where novel features exist (refer to paragraph II-2.1.7).

IV-2.1.12 Means of Functional Test

A means shall be provided for checking the recording system for proper operation as required by paragraph 2-1.4 of Section 2.

CHAPTER IV-3

MINIMUM PERFORMANCE SPECIFICATIONS UNDER STANDARD TEST CONDITIONS

IV-3.1 INTRODUCTION

This chapter specifies the minimum performance specification of the equipment and the levels to be demonstrated under standard test conditions.

IV-3.1.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F "Environmental Conditions and Test Procedures for Airborne Equipment" paragraph 3.4 as:

a Temperature :+15 to +35°C

b Relative Humidity : Not greater than 85%

c Ambient Pressure : 84 to 107 kPa

In addition to the above; the AC electrical power supply shall be within the limits specified as Normal in Section 16 of ED-14F/DO-160F or subsequent issue.

In the case of equipment designed for operation from an AC power source of variable frequency, unless otherwise specified, tests should be performed at representative input power frequencies with the input frequency adjusted to within 5% of a selected frequency.

IV-3.2 RECORDING SYSTEM MINIMUM PERFORMANCE LEVELS

The recording system shall be tested to show compliance with the following minimum performance levels.

***NOTE*:** *Where these paragraphs state requirements regarding the information in the recording medium, it should be interpreted as that observed at the output of the data retrieval equipment specified by the equipment manufacturer.*

IV-3.2.1 Start Up and Effects of Power Interruptions

Following a system electrical power interruption, the recovery characteristics of each component of the DLRS, including any networks and busses, shall be such that:

a Following initial application of power to the DLRS and any start logic is satisfied, or following an interruption with a duration of more than 200 milliseconds, the recording system shall commence and continue to store information, in accordance with the requirements of this MOPS, within 60 seconds.

b All information available at the start of an interruption together with that available in the following 200 milliseconds shall be recorded in the robust memory module.

c After 5 seconds at a normal power level, interruptions with duration of up to 200 milliseconds shall have no effect on the DLRS.

***NOTE 1*:** *The recording of data should commence immediately when data is available.*

***NOTE 2*:** *Any built-in-test function may take up to 5 seconds to recover. The recovery period of 5 seconds is intended to permit power-up test and system initialisation routines to be performed. It is recommended that such routines should be performed as rapidly as possible to minimise the recovery period.*

***NOTE 3*:** *No constraint is intended to be placed on maintenance actions associated with setting the initial configuration status of the system following equipment replacement.*

IV-3.2.2 Standard Message

A standard message is defined as 103 ASCII characters (or equivalent) of payload at the input to the recording system. Protocol or overhead required to identify the message during playback also be processed and stored. An example of required header/protocol information is the time stamp added to the message prior to it being sent to the recording system.

IV-3.2.3 Short Term Maximum Throughput

The recording system shall continue to operate in accordance with the other requirements of this chapter when it receives a burst of six consecutive message pairs at the interface's maximum possible input data transfer rate, with an interval of one minute between such bursts. These message pairs shall be as defined in paragraph IV-3.2.2.

CHAPTER IV-4

MINIMUM PERFORMANCE SPECIFICATIONS UNDER ENVIRONMENTAL TEST CONDITIONS

IV-4.1 INTRODUCTION

Chapter 2-3 of this document defines the environmental tests to be performed on the recording system.

Compliance with the applicable performance requirements of this part for DLRS shall be demonstrated as shown in TABLE IV-4.1.

IV-4.2 EXCEPTIONS TO GENERAL REQUIREMENTS

There are no exceptions to the general requirements defined in Chapter IV-3 for DLRS.

ENVIRONMENT	Test Reference ED-14F/DO-160F section	MOPS PARAGRAPH NUMBER			
		2-1.5 recorder Operation	IV-3.2.1 Power Interruption	IV-3.2.1 Recording Delay	2-1.10 Timebase Characteristics
Temperature	4	R	R	R	R
Altitude	4	R			
Temp Variation	5	R			R
Humidity	6	R			
Shock	7	R			
Vibration	8	R			
Magnetic Effect	15	R			
Power Input	16	R			
Voltage Spike	17	R			
AF Susceptibility	18	R			
Induced Susceptibility	19	R			
RF Susceptibility	20	R			
ESD	25	R			
RF Emission	21	R			

Key Blank = Manufacturer's Discretion E = Exceptions apply R = Test Required

TABLE IV-4.1: ENVIRONMENTAL TEST MATRIX FOR DATA-LINK RECORDING SYSTEM

CHAPTER IV-5

TEST PROCEDURES

IV-5.1 INTRODUCTION

This chapter specifies the standard test procedures for demonstrating compliance with Chapter IV-2 and Chapter IV-3. Although specific test procedures are cited, it is recognised that they will not apply in all cases and that other methods may be preferred or required. Alternative methods may be used if the manufacturer can show that they provide equivalent certification data.

Where a test procedure is not specified for a particular characteristic, the manufacturer may show compliance either by analysis or by devising a test appropriate to the equipment design. All test measurements shall be traceable to a recognized calibration standard.

The verification procedure of on board recording performance shall test that the Data-link data defined in this document is recorded correctly on board and can be retrieved to meet the requirements of this specification.

IV-5.1.1 Adjustment of Equipment

The equipment under test shall be properly aligned and adjusted in accordance with the manufacturer's recommendations.

IV-5.1.2 Test Instrument Precautions

Precautions shall be taken to prevent the introduction of errors resulting from impedance mismatch and the improper connection of test instruments to the equipment under test.

IV-5.1.3 Test Conditions

Unless specified as part of environmental testing, all tests shall be performed under the conditions specified in paragraph IV-3.1. Unless otherwise stated, the test procedures of this chapter apply to systems with digital processing inputs and digital processing outputs.

IV-5.1.4 Connected Loads

Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance values for which it is designed.

IV-5.1.5 Warm-up Period

Unless otherwise specified, all tests shall be performed after a warm-up (stabilisation) period of not less than 5 minutes and not more than 15 minutes.

IV-5.1.6 Recording of Test Results

Except where tests are ”Pass / Fail” in character (e.g. the determination of whether or not mechanical devices function correctly), the actual numerical values obtained for each of the parameters tested shall be recorded in a qualification test report.

IV-5.2 TEST PROCEDURES

IV-5.2.1 Continuity of Recording (paragraph IV-3.2.1)

It shall be verified that all data-link messages will be recorded continuously since the electrical power is applied to the system and the start logic is satisfied.

a Equipment Required:

i. Data-link message transfer simulation,

ii. Basic simulation of start/stop conditions,

iii. Readout Tool.

b Measurement Procedure:

i. Apply power to the recording system,

ii. Set the starting conditions to true,

iii. Start the message transfers simulation,

iv. Record for the duration as defined in paragraph IV-2.1.3,

v. Set the stop conditions to true,

vi. Readout the recorded data,

vii. Compare the recorded data with the data simulated.

All simulated data shall be recorded completely between Start/Stop conditions.

IV-5.2.2 Effects of Power Interruptions (paragraph IV-3.2.1)

It shall be verified that the requirements according to effects on power interruptions defined under paragraph IV-3.2.1 are fulfilled.

a Equipment Required:

i. Power interrupt generator,

ii. Data-link message transfer simulation,

iii. Basic simulation of start/stop conditions,

iv. Readout tool.

b Measurement Procedure:

i. Power Interrupt of 200 milliseconds under normal power level.

A. Apply power to the recording system,

B. Set the starting conditions to true,

C. Start the message transfer simulation,

D. Perform power interrupt of 200 milliseconds,

E. Set the stop conditions to true,

F. Readout the recorded data,

G. Compare the recorded data with the data simulated.

The data recorded shall be identical with the data simulated.

ii. Power Interrupt of more than 200 milliseconds under abnormal and emergency power level.

A. Equip abnormal or emergency power to the recording system,

B. Set the starting conditions to true,

C. Start the message transfer simulation,

D. Perform power interrupt of more than 200 milliseconds,

E. Set the stop conditions to true,

F. Readout the recorded data.

The data recorded shall be identical with the data simulated. The system shall recover and commence storing information within 250 milliseconds after the power is restored. The data recorded before the power interrupt and 250 milliseconds after power recovery shall be identical with the data simulated.

IV-5.2.3 Test of Delays (paragraph IV-2.1.5)

a Equipment Required:

i. Data-link message transfer simulation,

ii. Basic simulation of starting conditions,

iii. Readout tool,

iv. Logic analyser or equivalent time measurement equipment.

b Measurement Procedure:

The delay between the recording system input and recording shall be tested.

i. Apply power to the recording system,

ii. Set the starting conditions to true,

iii. Start the message transfer simulation with a standard message (as defined in paragraph IV-3.2.2),

iv. Measure time between the complete reception of the message at the recording device and the recording in the robust recording medium for each character by use of the logic analyser,

v. Set the stop conditions to true.

It shall be verified that the maximum time delay between the complete reception of the message at the recording device and the recording of the message in the robust medium does not exceed the figure as defined in paragraph IV-2.1.5.

IV-5.2.4 Recording Duration / Capacity (paragraph IV-2.1.3)

It shall be verified that the recording medium capacity is sufficient to store the digital messages specified in paragraph IV-2.1.3.

Subsequent playback of messages shall verify that the full test format was recorded.

a Equipment required:

i. Data-link message transfer simulator,

ii. Basic simulation of start/stop conditions,

iii. Readout tool.

b Measurement procedure:

i. Apply power to the recording system,

ii. Set up the message simulator in accordance with the scenario as specified in paragraph IV-2.1.3,

iii. Set the starting conditions to true,

iv. Start the message transfers simulator,

v. Continue simulation for duration as specified in paragraph IV-2.1.3,

vi. Set the stop conditions to true,

vii. Readout the recorded data,

viii. Compare the recorded data with the data simulated.

It shall be verified that all simulated data has been recorded.

IV-5.2.5 Short Term Maximum Throughput (paragraph IV-3.2.3)

It shall be verified that when a burst of data messages at the maximum burst throughput of paragraph IV-3.2.3 rate is sent to the recording system, all messages can be recovered as specified in paragraph IV-3.2.3.

a Equipment required:

i. Data-link message transfer simulator,

ii. Basic simulation of start/stop conditions,

iii. Readout Tool.

b Measurement procedure

i. Apply power to the recording system,

ii. Set simulator for the maximum message transfer rate,

iii. Set the starting conditions to true,

iv. Start the message transfers simulator,

v. Continue simulation for the period of time specified in paragraph IV-3.2.3,

vi. Set the stop conditions to true,

vii. Readout the recorded data,

viii. Compare the recorded data with the data simulated.

It shall be verified that all simulated data shall be recorded completely between Start/Stop conditions.

IV-5.2.6 Bit Error Rate (paragraph 2-1.6)

It shall be verified that the bit error rate arising from differences between the input and the retrieved data caused by corruption of the data during processing, recording and retrieval does not exceed the specification in paragraph 2-1.6.

a Equipment Required:

i. Data-link message transfer simulator,

ii. Basic simulation of start/stop conditions,

iii. Readout tool.

b Measurement procedure:

i. Apply power to the recording system,

ii. Set up the message simulator to generate test data,

iii. Set the starting conditions to true,

iv. Start the message transfers simulation,

v. Continue simulation for duration as specified in paragraph IV-2.1.3,

vi. Set the stop conditions to true,

vii. Readout the recorded data,

viii. Verify bit errors in recovered data are within allowance of paragraph 2-1.6.

All simulated data shall be recorded completely between Start/Stop conditions.

IV-5.2.7 Time Base Characteristics (paragraph 2-1.10**)**

It shall be verified that the time base used in the recording of the digital messages is stable to the specification of paragraph 2-1.10.

a Equipment required:

i. Data-link message transfer simulator,

ii. Basic simulation of start/stop conditions,

iii. Readout tool.

b Measurement procedure:

i. Apply power to the recording system,

ii. Set up the message simulator to generate accurately timed message intervals,

iii. Set the starting conditions to true,

iv. Start the message transfers simulation,

v. Continue simulation for duration as specified in paragraph IV-2.1.3,

vi. Set the stop conditions to true,

vii. Readout the recorded data,

viii. Verify all recovered messages are represent the overall time base stability characteristics specified in paragraph 2-1.10.

It shall be verified that all simulated data shall be recorded completely between Start/Stop conditions.

IV-5.2.8 Monitoring of Proper Operation

It shall be verified that the aural or visual means of pre-flight checking works as specified to ensure the digital message recording system is functioning correctly.

a Equipment required:

i. Data-link message transfer simulator,

ii. Basic simulation of start/stop conditions,

iii. Readout tool.

b Measurement procedure:

The following events shall lead to aural or visual indications:

i. loss of system electrical power,

Test sequence: shut down system electrical power

recording system shall produce failure indication output

ii. failure of the digital interface within the recording system,

Test sequence: simulate failure of the digital interface

recording system shall produce failure indication output

iii. failure of the recording medium,

Test sequence: simulate failure in the recording medium

recording system shall produce failure indication output

iv. failure of the recording system to store the information in the recording medium as shown by checks of the recording,

Test sequence: simulate failure in recording medium

recording system shall produce failure indication output

v. removal of the recording medium or any other item of this equipment from the aircraft,

Test sequence: remove recording medium, run communication system without recording system

recording system shall produce failure indication output

To prove the correct indication in the aircraft cockpit the tests have to be repeated under real aircraft conditions.

IV-5.2.9 Data Retrieval Characteristics

a Equipment required:

i. Data-link message transfer simulation,

ii. Basic simulation of start/stop conditions,

iii. Readout tool.

Data analysis tool and software (replay equipment)

b Measurement procedure:

i. Apply power to the recording system,

ii. Set the starting conditions to true,

iii. Start the message transfers simulation,

iv. Set the stop conditions to true,

v. Readout the recorded data,

vi. Compare the recorded data with the simulated data,

vii. Repeat this steps i. through vi.

Check that all recorded data of an undamaged, fully serviceable recording medium can be retrieved. Check that for an undamaged, fully serviceable recording medium with a corrupted record all data can be retrieved, including the corrupted record. Check that the data is not altered, degraded or overwritten after the first download. Check that the chronological order of the messages is maintained during replay.

CHAPTER IV-6

EQUIPMENT INSTALLATION AND INSTALLED PERFORMANCE

IV-6.1 INTRODUCTION

This chapter specifies ADRS installation characteristics and performance with procedures for verifying that performance when the system is installed in an aircraft. Installed performance criteria are generally the same as those contained in Chapter II-3, which were verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be confirmed after installation.

IV-6.2 GENERAL

A schedule of tests should be prepared by the equipment installer. For the prototype installation, a comprehensive programme of tests should be performed, as described in paragraphs IV-6.3 and IV-6.4.

Following the testing of each new DLRS installation, the recording so obtained shall be evaluated to confirm adequate message recording accuracy and synchronisation with other recording devices both on the aircraft and on the ground.

Similarly it will be necessary to evaluate recording obtained from in-service flying to ensure this accuracy is maintained and the system has sufficient capacity to preserve all messages received over the required recording duration.

***NOTE*:** *The recording performance test can be conducted in a laboratory environment or in the real aircraft environment.*

An analysis shall be performed by the equipment installer to identify the “subsystems” where the serviceability or accuracy could be degraded and remain undetected. Maintenance tasks shall take account of this analysis by requiring the appropriate calibration checks at suitable intervals.

During introduction to service of a new component in the DLRS, in order to test the correct operation of the overall recording system, a scenario has to be developed. In the course of the scenario, one or more procedures, involving the pilots of an aircraft, a ground station such as an ATC centre (or a simulation thereof) should be exercised. There may be benefit in performing the test twice, once with an ATM centre and once with a non-ATM centre.

A complete test scenario consists of three test domains

a Aircraft recording domain

b Ground recording domain (or simulation)

c Correlation of recording domains (end-to-end test)

NOTE: *It shall not be required to test the data-link technology itself. The data-link establishment, test and approval are described in the EUROCAE document ED-78A/RTCA document DO-264. The test procedures shall focus on the data-link overall recording system comprising on board recording, ground recording and correlation of both recording domains.*

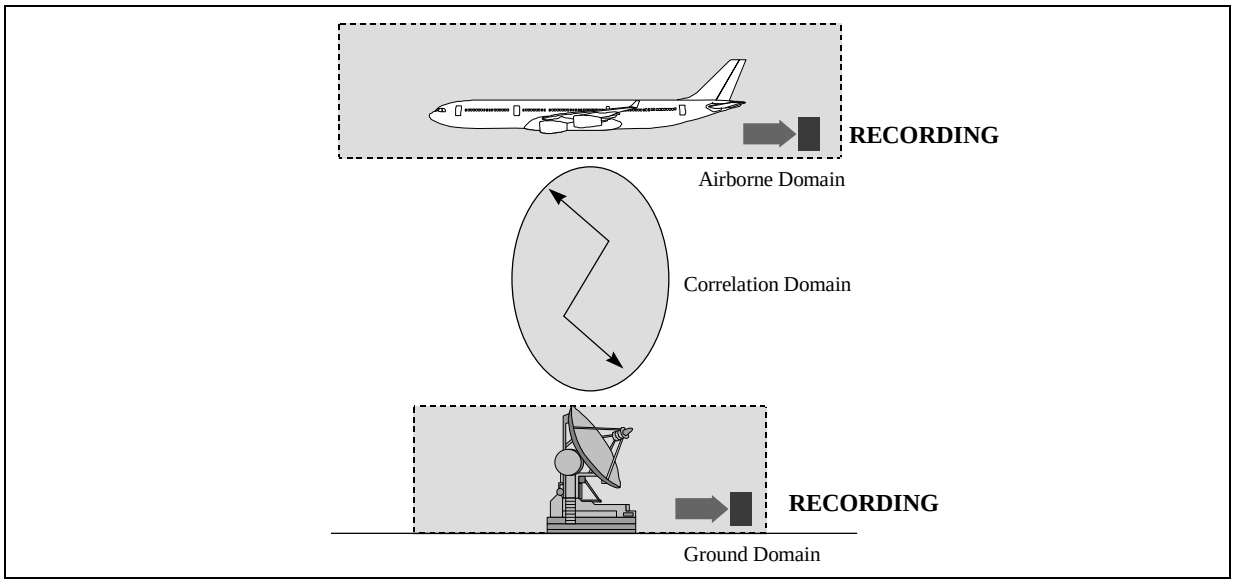


FIGURE IV-6.1: TEST DOMAINS

The verification of a communication data recording shall be done in order to correlate the message flows between both parts.

- on the aircraft, and
- simultaneously on the ground

It shall be verified that

- the actual or deduced message content for airborne recording is correct (through comparison with ground recordings or equivalent means),
- a synchronisation with a common time base is possible,
- the reconstitution of message sequences in the scenario is possible.

***NOTE*:** *Standardisation of recording formats may make automatic correlation of these messages possible.*

A test procedure shall include following activities:

a send messages (different types) from the ground equipment to the aircraft and vice versa,

b perform the communication on the aircraft and on the ground (both digital message generation and voice commenting) in order to be able to correlate voice and data communication,

c retrieve the data after the test from the aircraft recording system on ground,

d Check airborne recording (e.g. through the ground recording) and confirm the integrity of on board data.

***NOTE*:** *It is recommended that anyone operating an aircraft equipped with the data-link communication system shall have the possibility to obtain an audit to recover data-link messages from their network provider. The operator may ensure this by requesting a data recovery of all available data-link messages for a single randomly selected flight. The recommended frequency is once per year. This procedure will ensure identification of any deficiencies in the service provider's capabilities.*

IV-6.3 GROUND TEST PROCEDURES

IV-6.3.1 General

This section provides guidance for ground testing the initial installation of a unique system in an aircraft. It may need to be adapted to suit the particular installation being tested and to comply with operating regulations.

Each unique recording system shall be ground tested, and the recording so obtained shall be evaluated to show adequate recording quality during all test conditions.

The replay and evaluation shall be performed by a replay centre acceptable to the certification authority.

IV-6.3.2 Downlink (From Aircraft)

a Send a standard message (as defined in paragraph IV-3.2.2) to an ATC centre.

b Note content of message and time message was sent.

c With an available selection of several messages on the data entry panel, select the messages randomly (i.e. Read, Skip, Delete, Store, Recall etc.).

d Note message selected, activity, and time when selected.

e Verify the airborne recording meets the requirements of paragraph IV-2.1.6.

f Verify airborne and ground recording message content, and time stamps correspond to those noted in b and d.

g Repeat a through f using a non-ATC centre.

IV-6.3.3 Uplink (To Aircraft)

a Send a standard message (as defined in paragraph IV-3.2.2) to the aircraft from an ATC centre.

b Note content of message and time message was sent.

c On the aircraft using the data entry panel select the message uplinked to the aircraft (i.e. Read, Skip, Delete, Store, Recall etc.).

d Note message selected, content, activity, and time when selected.

e Verify the airborne recording meets the requirements of paragraph IV-2.1.6.

f Verify airborne and ground recording message content, and time stamps correspond to those noted in b and d.

g Repeat a through f using a non-ATC centre.

IV-6.3.4 Conformity Inspection

a Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices.

b Verify that proper mechanical and electrical connections have been made and that the equipment has been located and installed in accordance with the requirements and the manufacturer's recommendations.

IV-6.3.5 Equipment Function

Vary all controls of the equipment through their full range to determine that the equipment is operating according to the manufacturer's instructions and that each control performs its intended function.

IV-6.3.6 Interference Effects

a With the recording equipment in normal and standby operation, operate other electrically operated aircraft equipment and systems to determine that no significant levels of conducted or radiated interference exist.

b Evaluate all combinations of control settings and operating modes.

c Operate communication and navigation equipment on the low, high and at least one mid-band frequency.

d Identify systems or modes of operation that should be evaluated during flight.

e If appropriate, repeat the tests using emergency power with the aircraft's batteries alone and any standby inverters operating.

IV-6.3.7 Power Supply Fluctuations and Protection

a Under normal aircraft conditions, cycle the aircraft engine(s) through all normal power settings and verify the proper operation of the equipment.

b Isolate the electrical supply to the recording system by means of the protective devices provided (e.g. circuit breakers) and verify that the equipment is off.

IV-6.4 FLIGHT TEST PROCEDURES

This procedure assumes that a complete system test of the data-link communication system aircraft installation has been successfully conducted.

If an on-board printer is available, print all Uplinks and Downlinks for correlation and verification with the recordings. If the requirements have been successfully demonstrated during ground testing a flight test may not be necessary.

IV-6.4.1 General

a This section provides guidance for flight testing the initial installation of a unique system in aircraft. It may need to be adapted to suit the particular installation being tested and to comply with operating regulations.

b Each unique recording system shall be flight tested, and the recording so obtained shall be evaluated to show adequate recording quality during all normal regimes of flight including taxiing, takeoff, cruise, approach and landing.

c The replay and evaluation shall be performed by a replay centre acceptable to the Certification Authority.

IV-6.4.2 Downlink (From Aircraft)

a Send a standard message (as defined in paragraph IV-3.2.2) to an ATC centre.

b Note content of message and time message was sent.

c With an available selection of several messages on the data entry panel, select the messages randomly (i.e. Read, Skip, Delete, Store, Recall etc.).

d Note message selected, activity, and time when selected.

e Verify the airborne recording meets the requirements of paragraph IV-2.1.6.

f Verify airborne and ground recording message content, and time stamps correspond to those noted in b) and d).

g Repeat a) through f) using a non-ATC centre.

IV-6.4.3 Uplink (To Aircraft)

a Send a standard message (as defined in paragraph IV-3.2.2) to the aircraft from an ATC centre

b Note content of message and time message was sent.

c On the aircraft, using the data entry panel, select the message uplinked to the aircraft (i.e. Read, Skip, Delete, Store, Recall etc.).

d Note message selected, content, activity, and time when selected.

e Verify the airborne recording meets the requirements of paragraph IV-2.1.6.

f Verify airborne and ground recording message content, and time stamps correspond to those noted in b) and d).

g Repeat a) through f) using a non-ATC centre.

IV-6.5 POST FLIGHT EVALUATION OF RECORDINGS

IV-6.5.1 Introduction

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

IV-6.5.2 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.

IV-6.5.3 Recording Evaluation

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

IV-6.5.4 Verification of Ground Recording Performance

The Verification of Ground Recording Performance is out of the scope of this document.

IV-6.5.5 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.

ANNEX IV-A

DATA-LINK RECORDING TABLE

IV-A.1 DATA TO BE RECORDED

The material in the Table IV-A.1 is to be considered as guidance material only and as a means of compliance with the MASPS ED-93.

IV-A.1.1 Table IV-A.1 lists the function and states if the appropriate data shall be recorded,

a on ground, or

b on board.

c Depending on the type of information this data has to be differentiated between

i. data-link messages to be recorded either with full content or just the identifier code saying, that the data reached/left the aircraft,

ii. parameters to be recorded on the ADRS part.

NOTE 1: *The full content of the ARINC 623 ATC type messages shall be recorded.*

***NOTE 2*:** *For AOC/AAC messages as per ICAO definition (refer to paragraph 1-1.5.1), the origin/destination code of messages) sent to/generated by the ATSU/CMU, FMS, CMS, ACMS, or Printer shall be the minimum data to be recorded, if practicable within the system architecture, (per Table IV-A.1) but this does not preclude recording of additional data.*

NOTE 3: *ADS data shall be recorded as defined in Table IV-A.1 because some parameters contained in the ADS report are transmitted by voice today (e. g. two, three next waypoints). ADS data supports the task of accident investigation, because they allow the reconstruction of the aircraft/controller scenario.*

TABLE IV-A.1: DATA-LINK RECORDING APPLICATIONS

Item No.	Application Type	Application Description	Required Recording Content
1	Data-link Initiation	This includes any applications used to logon 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 pilots 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 (ADS-C) application. Where parametric data is reported within the message it shall be recorded unless data from the same source is recorded on the ADRS.	C
4	Flight Information	This includes any application used for delivery of flight information data to specific airplanes. This includes D-ATIS, D-OTIS, text weather services, NOTAM delivery, etc.	C
5	Aircraft Broadcast Surveillance	This includes Elementary and Enhanced Surveillance Systems, as well as ADS-B output data. Where parametric data sent by the aeroplane, is reported within the message it shall be recorded unless data from the same source is recorded on the ADRS.	M *
6	Aeronautical Operational Control Data	This includes any application transmitting or receiving data used for AOC purposes (per the ICAO definition of AOC).	M *

***NOTE*:**

C: Complete contents recorded

M: Information that enables correlation to any associated records stored separately from the aircraft

**: Applications that are to be recorded only as far as is practicable given the architecture of the system*

ANNEX IV-B

MAINTENANCE PRACTICES

IV-B.1 GENERAL

IV-B.1.1 The maintenance tasks required to ensure the continued serviceability of the installed DLRS will depend on the extent of monitoring built into the DLRS. Appropriate inspections and functional checks, together with the intervals at which these should be performed are described in Table IV-B.1

IV-B.1.2 Maintenance procedures should emphasise the need to preserve the recording following a reported incident.

IV-B.2 RECORDING EVALUATION

IV-B.2.1 An in-flight recording should be replayed and assessed for quality.

IV-B.3 PRIMARY MAINTENANCE TASKS

Table IV-B.1 shows the primary maintenance tasks for the installed DLRS.

Item	Task	Maximum Interval	Interpretation
1	Operational Check	Daily or prior to each flight	Confirm serviceability using TEST function on DLRS controller or Check 'no-fail' indication for built in test
2	System check and replay	As agreed between operator and regulatory authority (24 months recommended)	Carry out a lossless download of the DLRS recordings immediately post-flight. Replay and evaluate the quality of the in-flight recording.

TABLE IV-B.1: MAINTENANCE TASKS AND INTERVALS

WG-77 MEMBERSHIP

NAME	FIRST NAME	COMPANY
PLANTIN DE HUGUES (Chairman)	Philippe	BEA
CASH (Secretary)	Jim	NTSB US
AIGOIN	Guillaume	EASA
BARBAGALLO	Pietro	ENAC
BARBERAN	Cros	FOMENTO
BATCHELLER	David	APPAREO
BETZOLL	Andreas	PILATUS
BLAU	George	BFU
BLEISS	Jan	
BODU LAVIGNE	Dany	RESEDA
BOMMER	Otto	BECKER AVIONICS
BORST	Addy	KLM
BOSWORTH	Duncan	ATSB
BOULANGER	Chantale	L3 COMMUNICATIONS
BOWLES	Gregory	GAMA
BREL	Hervé	BECKER AVIONICS
BULMER	Geoffrey	BEC NAVIGATION LIMITED
BUTTNER	Seth	CESSNA AIRCRAFT COMPANY
CAILLE	Jean-Pierre	ETEP
CECIL	William	TELEDYNE CONTROLS
CHAMBERLAIN	Paul	PENNY & GILES AEROSPACE
COLIN	Michel	AIRBUS
CONDETTE	Johan	BEA
COOKSON	Maurice	FAA
CREMER	Matthias	MESSWERK
CUSHMAN	Anna	FAA
DAMIEN	PierreJean	IAERO
DAURES	Luc	EUROCOPTER
DAWSON-MADDOCKS	Andrew	ADM SHINE TECHNOLOGIES Ltd
DU BEDAT	Arnaud	IFALPA
DUCOIN	Gérald	IAERO
ELLINGSTAD	Vernon	US NTSB
ELLIOTT	Jim	SMITHS AEROSPACE
EVANS	Carolyn	BALPA
FERRY	Wendy	UNIVERSAL AVIONICS
FOX	Roy	BELL HELICOPTERS
GIVINS	Ted	TSB CANADA
GORMLEY	Erin	NTSB US
GREILLER	Marc	EUROCOPTER
GREWE	Reinhold	EADS DEUTSCHLAND GmbH
GROSSI	Dennis	FLIGHTSCAPE
GUAN	Michael	ASC
HALL	Garth	CESSNA AIRCRAFT COMPANY
HANSON	James	HELIOS TECHNOLOGY
HARTUNG	Dirk	THIELERT

HENNIG	Jens	GAMA
HORIKOSHI	Fumiki	ARAIC
HORNE	Michael	A.D. AEROSPACE Ltd
HUCKLESBY	Julian	QINETIQ
JAMES	Richard	AAIB
KALINKA	Holger	KAPI ELECTRONICS GmbH
KELL	Kenneth	ATSB
KIDD	Nick	PENNY & GILES AEROSPACE
KINOSZ	Casey	GAMA
KLEINE-BEEK	Werner	EASA
KOORT	Edwin	CIRCUITLINK
KRAMAR	Peter	TSB CANADA
KUNZE	Dieter	BECKER AVIONICS
LABORDE	Gregory	TEAM
LACIPIERE	Bernard	ECT
LEAPER	Steve	PENNY & GILES AEROSPACE
LOPEZ	Dominique	FLIGHT DATA VISION
LUKENS	John	PRATT & WHITNEY
MACMASTER	Marc	NRC
MARCELLET	Jean-Claude	ISEI
MARTINEC	Daniel	ARINC
MASOERO	Gino	MUIRHEAD AVIONICS
MC CAULEY	Mike	AIRBORNE ANALYTICS
MC CLARY	Mike	CESSNA AIRCRAFT COMPANY
MERCALOV	Kerstin	KAPI ELECTRONICS GmbH
METZDORF	Bodo	THIELERT
MIAS	Florent	IAERO
Miller	Bradley	CIRRUS DESIGN CORPORATION
MONGINY	Nathalie	DCS DGAC
MONTILLOT	Patrick	BEA DEFENSE
MOORE	Pippa	CAA
MORLEY	Derek	PIRESEARCH
MORRISON	Brian	ALAKAI TECH CORP
NAHAPETIAN	Armen	TELEDYNE CONTROLS
PILGRIM	Mike	EUROCOPTER
PITSCHEIDER	Armin	EUROCOPTER
POLITIS	Elias	NRC
QUACKENBUSH	Gary	SMITHS AEROSPACE
RAMDEEN	Steve	FAA
REDA	Rasheed	ETC USA
RIDGELY	Timothy	BOEING COMPANY
RITSCHEL	Dieter	LUFTFAHRT-BUNDESAMT
SALAMERO	Alain	ISEI
SAYADIAN	Albert	FAA
SCHICK	Arthur	EADS DEUTSCHLAND GmbH
SCHUURMAN	Michiel	DSB
SEBAN	Henri	EUROCOPTER
SHAVER	Timothy	FAA
SHU	Ping	GCAAC
SIMON	Jared	PHI HELICO
STEFFLER	Joe	GE

STEINBERG	Markus	THIELERT
STELLY	Carl	PHI HELICO
SYSLO	Joe	EUROCOPTER USA
TAYLOR	James	
TERRY	Malcolm	IFALPA
THOMPSON	Michael	HONEYWELL AEROSPACE
TROMEUR	Daniel	CEAT
VALINKER	Hager	KAPI ELECTRONICS GmbH
VAN DEN HEUVEL	Blake	DRS DATA and IMAGING SYSTEMS
VAN DER ELST		MEV
VERNA	Brian	FAA
VINCENT	Tom	HONEYWELL AEROSPACE
WALBROU	Frederic	BEA
WANG	Haofeng	CAST
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