

# AMDAR Onboard Software Functional Requirements Specification

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## FOREWORD

The WMO Aircraft Meteorological Data Relay (AMDAR) observing system is a subcomponent of the WMO Global Observing System, which is defined and maintained under the WMO World Weather Watch Program. AMDAR now provides more than 400,000 meteorological observations per day on the WMO Global Telecommunications System and comprises over 3000 commercial jet aircraft that collect and report high quality wind and temperature data according to WMO specification, utilizing predominantly onboard sensors and computing and avionics systems. This excellent collaboration between National Meteorological and Hydrological Services and the airline industry provides a highly valued supplement to the more conventional sources of upper air meteorological data derived from the satellite and radiosonde monitoring programs.

At the current time, there is still considerable potential for growth and expansion of the AMDAR observing system. This expansion would improve tropospheric upper air data coverage over many currently data-sparse areas of the globe and, as has been demonstrated from the knowledge and measurement of the significant positive impacts the data product has on numerical weather prediction computer models and forecast applications, would have considerable benefits for meteorological applications and related data user communities and the aviation industry.

This document provides a functional specification for AMDAR onboard software, which can be utilized by avionics software developers to build avionics software applications for AMDAR that will efficiently meet WMO standards and requirements for reporting of meteorological data from the aircraft platform utilizing aviation communications protocols and infrastructure.

I wish to thank the consultant, Mr Frank Tamis, who worked under the direction of the former WMO AMDAR Panel and the CBS Expert Team on Aircraft-Based Observing Systems in the compilation of the initial drafts of the specification and also the Members of the CIMO Task Team on Aircraft-based Observations who were responsible for the final revisions and assessment for publication. Thanks are also expressed to the WMO Secretariat for overall coordination of the work and expert input to the specification.



(Prof. B. Calpini)

President

Commission for Instruments and  
Methods of Observation

# Table of Contents

<b>1</b>	<b>INTRODUCTION</b>	<b>8</b>
1.1	BACKGROUND	8
1.2	OBJECTIVES	8
1.3	INTENDED AUDIENCE AND SCOPE	8
1.4	CONVENTIONS	9
1.5	APPLICABLE DOCUMENTS	9
1.6	ABBREVIATIONS AND ACRONYMS	10
<b>2</b>	<b>AMDAR SYSTEM OVERVIEW</b>	<b>11</b>
2.1	AMDAR SYSTEM	11
2.2	AMDAR ONBOARD COMPONENT OF THE AMDAR SYSTEM	12
2.3	OTHER SPECIFICATIONS	14
2.3.1	ARINC 620 versus this document	15
2.4	FURTHER READING	17
<b>3</b>	<b>AMDAR ONBOARD SOFTWARE REQUIREMENTS</b>	<b>18</b>
3.1	DATA ACQUISITION	19
3.2	DATA HANDLING	21
3.2.1	Data acquisition rate	21
3.2.2	Data Validation	21
3.2.3	Data Smoothing	22
3.2.4	Derived Parameters	22
3.2.4.1	<i>Phase of Flight</i>	22
3.2.4.1.1	Ground	22
3.2.4.1.2	Ascent	22
3.2.4.1.3	En-Route	22
3.2.4.1.4	Descent	23
3.2.4.2	<i>Turbulence Metric</i>	23
3.2.4.3	<i>Water Vapor / Relative Humidity / Dew Point</i>	23
3.2.4.4	<i>Roll Angle Flag</i>	23
3.2.4.5	<i>Aircraft Configuration Indicator</i>	24
3.3	AMDAR OBSERVATIONS	25
3.3.1	Ascent Initial Observation	26
3.3.2	Ascent Observations	26
3.3.3	Descent Observations	27
3.3.4	Routine Observations	27
3.3.4.1	<i>Ascent Routine Observations</i>	27
3.3.4.2	<i>En-route Routine Observations</i>	27
3.3.4.3	<i>Descent Routine Observations</i>	27
3.3.4.4	<i>Maximum Wind Observation</i>	27
3.3.5	EDR Routine Observations	28
3.3.6	Touch-down Observation	28
3.4	FLIGHT PHASES AND REPORTING SCHEMES	28

3.4.1	Pressure Based Scheme .....	29
3.4.1.1	<i>Ascent</i> .....	29
3.4.1.1.1	Ambient Static Pressure at Take-Off .....	29
3.4.1.1.2	Initial Ascent Observation .....	30
3.4.1.1.3	Ascent Part 1.....	30
3.4.1.1.4	Ascent Part 2.....	30
3.4.1.1.5	Ascent Routine Observations .....	30
3.4.1.2	<i>Descent</i> .....	30
3.4.1.2.1	Touch-down Observation .....	31
	The Touch-Down observation should be made and stored before and as close as possible to the time of the ON event.....	31
	Touch-down Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported. ....	31
3.4.1.2.2	Descent Routine Observations .....	31
3.4.2	Time Based Scheme .....	31
3.4.2.1	<i>Ascent</i> .....	31
3.4.2.1.1	Initial Ascent Observation .....	31
3.4.2.1.2	Part 1 .....	31
3.4.2.1.3	Part 2 .....	31
3.4.2.2	<i>Descent</i> .....	31
3.4.2.2.1	Touch-down Observation .....	32
3.5	MESSAGE COMPILATION .....	32
3.5.1	Content .....	32
3.5.2	Format.....	32
3.5.2.1	<i>ACARS messages</i> .....	32
3.5.3	Transmission Requirements.....	32
3.6	SOFTWARE CONFIGURATION CONTROL .....	34
3.6.1	Observation Frequency Control.....	34
3.6.2	Reporting Control.....	36
3.6.2.1	<i>Reporting on/off</i> .....	36
3.6.2.2	<i>Geographical Control boxes</i> .....	37
3.6.2.3	<i>Airport specific reporting</i> .....	37
3.6.2.4	<i>Time Limiting</i> .....	38
3.6.2.5	<i>EDR Event message settings</i> .....	38
3.6.3	Configuration Message .....	38
3.6.4	AMDAR Optimization Message.....	39
<b>APPENDIX A</b>	<b>AOSFRS MESSAGE FORMAT FOR ACARS VERSION 01 .....</b>	<b>40</b>
A.1	INTRODUCTION .....	40
A.2	HEADER BLOCK .....	40
A.3	DATA BLOCK.....	41
A.3.1	Basic Observation Sequence .....	41
A.3.2	Optional Parameters .....	41
A.4	EDR EVENT MESSAGE.....	45
<b>APPENDIX B</b>	<b>ADDITIONAL AOSFRS DOWNLINK MESSAGES .....</b>	<b>48</b>
B.1	AOSFRS CONFIGURATION MESSAGE .....	48
B.2	AOSFRS OPTIMIZATION MESSAGE.....	50
<b>APPENDIX C</b>	<b>OPTIONAL DERIVED PARAMETERS .....</b>	<b>51</b>

C.1	TURBULENCE .....	51
C.1.1	Derived Equivalent Vertical Gust (DEVG).....	51
C.1.2	Eddy Dissipation Rate (EDR).....	53
C.1.2.1	<i>EDR Calculations Algorithm</i> .....	53
C.1.2.2	<i>EDR Reporting Algorithm</i> .....	53
C.2	ATMOSPHERIC WATER VAPOR CONTENT.....	57
C.2.1	The WVSSII Sensor .....	58
C.2.1.1	<i>Introduction</i> .....	58
C.2.1.2	<i>Current Input Variables and Calculation</i> .....	58
C.2.1.3	<i>Presenting the 5-character Mixing Ratio Field</i> .....	59
C.2.1.4	<i>The Quality Control Character (Q)</i> .....	59
<b>APPENDIX D</b>	<b>DATA COMPRESSION.....</b>	<b>61</b>
D.1	BASE-40 COMPRESSION .....	61
D.2	MESSAGE FORMAT, COMPRESSED.....	62
<b>APPENDIX E</b>	<b>PLATFORM SPECIFIC INFORMATION.....</b>	<b>66</b>
E.1	HONEYWELL DATA SYSTEMS .....	66
E.2	TELEDYNE CONTROLS DATA SYSTEMS .....	67
<b>APPENDIX F</b>	<b>AVIONICS INFORMATION FORM .....</b>	<b>68</b>
<b>APPENDIX G</b>	<b>AOSFRS VERSION CONTROL.....</b>	<b>69</b>

# 1 Introduction

## 1.1 Background

The Global Aircraft Meteorological Data Relay (AMDAR) Program is a program initiated by the World Meteorological Organization (WMO) in cooperation with aviation partners, and is used to collect meteorological data worldwide from commercial aircraft. The WMO AMDAR Observing System is a sub-component of the WMO Global Observing System, which is defined and maintained under the WMO World Weather Watch Program<sup>1</sup>.

Existing aircraft onboard sensors, computers and communications systems are utilized to collect, process, format and transmit the meteorological data to ground stations via satellite or radio links. Once on the ground, the data is relayed to National Meteorological and Hydrological Services (NMHS), where it is processed, quality controlled and transmitted on the WMO Global Telecommunications System (GTS).

The data collected is used for a range of meteorological applications, including, public weather forecasting, climate monitoring and prediction, early warning systems for weather hazards and, importantly, weather monitoring and prediction in support of the aviation industry.

## 1.2 Objectives

This document provides a comprehensive functional specification for onboard AMDAR software. It is intended that the specification provides sufficient information to enable detailed technical specifications to be provided for AMDAR Onboard Software implementation on suitable avionics platforms.

## 1.3 Intended Audience and Scope

The specification is primarily intended for use by both meteorological agencies and avionics software developers to allow them to jointly develop AMDAR software with minimal additional information. It defines the Functional Specifications of the AMDAR Onboard Software only. Functional Specifications of other parts of the AMDAR data flow, such as ground-based processing, are outside its scope.

The specification will be applicable for all kinds of on-board data processing and communications system solutions, including ACARS and/or successors.

By definition, an aircraft-based meteorological observing system that conforms to this specification, and most particularly to those requirements that are designated as required (see conventions, paragraph 1.4), can be considered an AMDAR observing system.

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<sup>1</sup> The WMO World Weather Watch Programme: [http://www.wmo.int/pages/prog/www/index\\_en.html](http://www.wmo.int/pages/prog/www/index_en.html)

## 1.4 Conventions

The key words "must", "must not", "required", "shall", "shall not", "should", "should not", "recommended", "may", and "optional" in this document are to be interpreted as follows:

1. The terms "SHALL", "REQUIRED" or "MUST" mean that the definition is an absolute requirement of the specification.
2. The phrases "SHALL NOT" or "MUST NOT" mean that the definition is an absolute prohibition of the specification.
3. The terms "SHOULD" or "RECOMMENDED" mean that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
4. The phrases "SHOULD NOT" or "NOT RECOMMENDED" mean that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
5. The terms "MAY" or "OPTIONAL" mean that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product while another vendor may omit the same item. An implementation which does not include a particular option MUST be prepared to interoperate with another implementation which does include the option, though perhaps with reduced functionality. In the same vein an implementation which does include a particular option MUST be prepared to interoperate with another implementation which does not include the option (except, of course, for the feature the option provides.)

## 1.5 Applicable Documents

Where appropriate, references are provided to WMO, International Civil Aviation Organization (ICAO), Aeronautical Radio Incorporated (ARINC) or other documents that are subject to issue and review by the respective organizations. No recommendations or other information in this specification overrides or supersedes the requirements contained in referenced documents, unless specified otherwise.



## 1.6 Abbreviations and Acronyms

ACARS	Aircraft Communication Addressing and Reporting System
ACMS	Aircraft Condition Monitoring System
AMDAR	Aircraft Meteorological Data Relay
AOS	AMDAR Onboard Software
ARINC	Aeronautical Radio, Incorporated
ASDAR	Aircraft to Satellite Data Relay
DAS	Data Acquisition System
DEVG	Derived Equivalent Vertical Gust
EDR	Eddy Dissipation Rate
FMC	Flight Management Computer
GNSS	Global Navigation Satellite System
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IRS	Inertial Reference System
NCAR	National Center for Atmospheric Research (USA)
NMHS	National Meteorological and Hydrological Service
Q/C	Quality Control
SAT	Static Air Temperature
TAT	Total Air Temperature
UTC	Universal Time Coordinate
WMO	World Meteorological Organization
VHF	Very High Frequency

## 2 AMDAR System Overview

### 2.1 AMDAR system

The AMDAR system is defined by the characteristic that it is a meteorological observing system that utilizes aircraft innate sensors and onboard avionics and communications systems in order to collect process and transmit meteorological data that has been defined, sampled and processed according to WMO meteorological specifications.

The full AMDAR system comprises the end-to-end system of processes and practices, starting from measurement by aircraft sensors right through to the delivery of the data to Data Users. On the aircraft, Aircraft Data Computers obtain, process and format data from onboard sensors, and transmit data to ground via standard aircraft communication systems. Once on the ground the data are usually relayed to the National Meteorological and Hydrological Services (NMHS) and other authorized users as shown in Figure 1. Data are received at the data processing centers of the NMHS where they are decoded and undergo basic quality control checks before being reformatted for distribution to Data Users both internal to the NMHS and externally to other NMHSs via the WMO Global Telecommunication System (GTS).

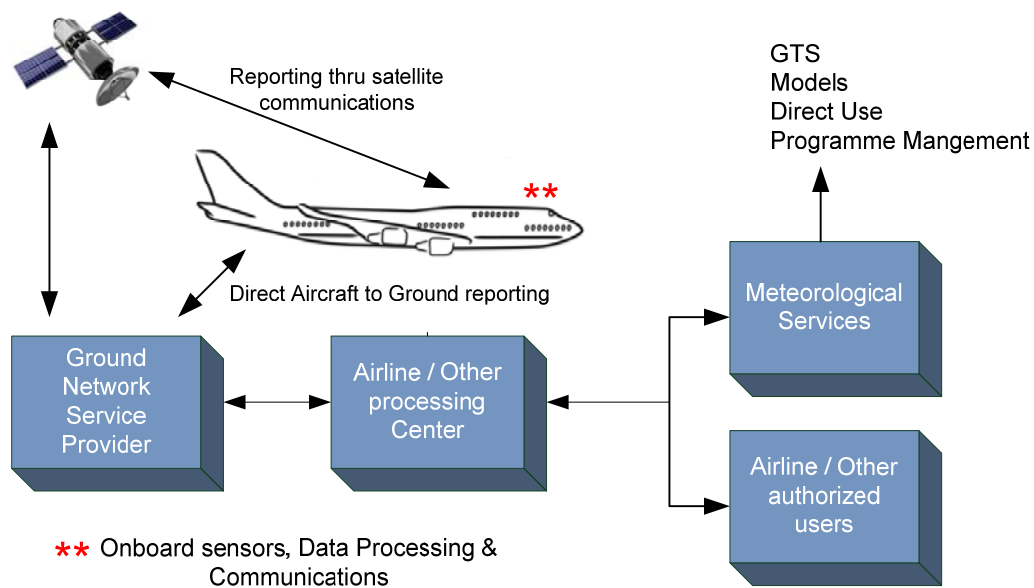


Figure 1: Typical AMDAR Data Flow

This document is concerned only with the specification of functional requirements for the airborne or onboard software component of the AMDAR system, the AMDAR Onboard Software.

## 2.2 AMDAR Onboard Component of the AMDAR System

The purpose of the airborne part of the AMDAR onboard system is to collect, process and transmit meteorological data from sensors onboard the aircraft.

To meet this purpose, AMDAR relies on the availability of onboard data acquisition systems that are capable of being programmed to perform the required functions through the implementation of the AMDAR Onboard Software, as specified within this document. Therefore, the first and most fundamental requirement of the AMDAR Onboard System is that the aircraft must have a Data Acquisition System (DAS) that is programmable and supports interfacing to all the required data inputs and to the aircraft communications system.

Figure2 shows schematically the principal data sources feeding into a Flight Management System and together forming the DAS. Note that the configurations and availability of systems vary widely between aircraft models and airline fleets.

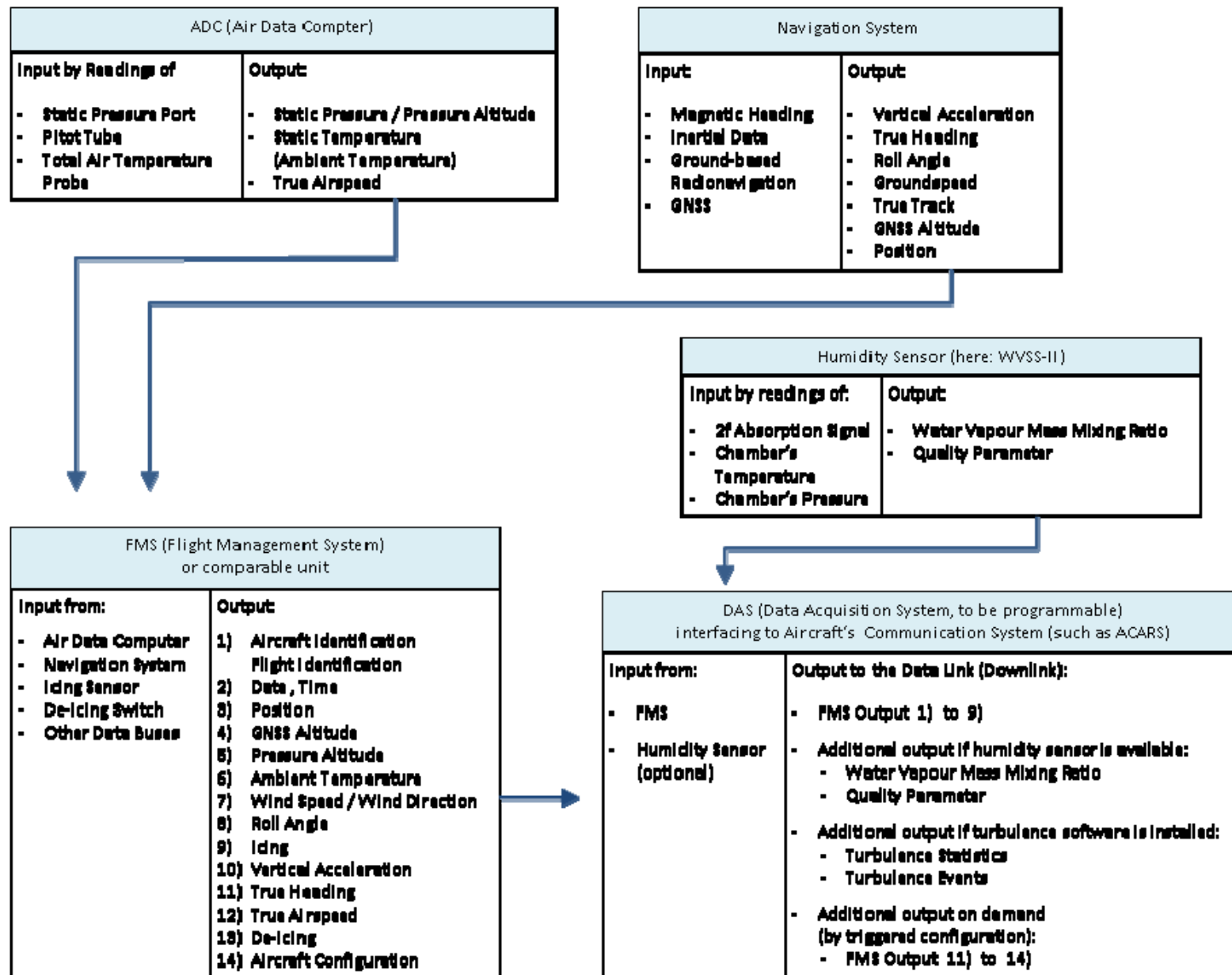


Figure2: AMDAR Onboard System, Data Acquisition System components with inputs and outputs.

Typical inputs to the DAS are, for example, Pressure Altitude, Static Air Pressure, Wind Speed, Wind Direction and others. These input parameters are processed by the AMDAR Onboard Software according to predefined sampling frequencies and the resulting data variables are stored as meteorological "Observations". Then, depending on the communications system used and requirements associated with message costs and efficiency, data latency, phase of flight and other parameters, when the required number of observations has been obtained, they are written to a standardized message that is subsequently sent to the ground.

By taking advantage of two-way aircraft-to-ground communications that are often available with modern aircraft avionics and communications systems, it is possible to facilitate modification of AMDAR Onboard Software program parameters via commands embedded within uplink messages, which are usually compiled and sent by automated, ground-based control systems in near real-time. This process is known as "AMDAR data optimization". AMDAR optimization systems allow NMHS and airlines to manage data volumes by avoiding redundant observations and messages through real-time AMDAR software modification either prior to or during aircraft flight and on an automated, flight-by-flight basis.

The end result of the AMDAR Onboard Component and the AMDAR Onboard Software is the production of the AMDAR messages containing the meteorological observations. These messages are transmitted to the ground by suitable data link communication systems and relayed by aviation Data Service Providers to the NMHS. The contents of the messages are processed and the data are ingested into meteorological databases and applications.

### **2.3 Other Specifications**

At the current time, the AMDAR Observing System utilizes the ACARS communications standards and message protocols for the transmission of AMDAR data from the aircraft to ground and for ground-based message relay. ACARS is short for Aircraft Communications Addressing and Reporting System and is a digital data link system for transmission of short, relatively simple telex format messages between aircraft and ground stations via radio or satellite. The protocol was designed by Aeronautical Radio, Incorporated (ARINC). For more information on ACARS see ARINC618-6 appendix B

AMDAR takes advantage of the free text area available within ACARS messages and so, theoretically, there is no need to maintain a specification of AMDAR message formats within the ARINC ACARS standards. Therefore, there are many possible format specifications for meteorological messages from aircraft using ACARS. However, in order to avoid the proliferation of data formats and reduce the overheads and complexity for compliance by ground processing systems it is important to minimize the number of standards and protocols in use. This document provides a functional requirements specification that will be known as the AMDAR Onboard Software (AOS) Functional Requirements Specification (AOSFRS). This specification is based on the ASDAR Specification<sup>2</sup>, the E-

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<sup>2</sup> Software Requirements Specification for the ASDAR Project, Issue 3, Matra Marconi Space UK Limited, October 1994 (reference 1163-00016-44-4).

AMDAR AAA Version 2.0 Specification (AAA V2)<sup>3</sup> and the AMDAR AAA Version 3.0 specification (AAA V3)<sup>4</sup>. All information in this document supersedes the previously mentioned documents.

Some information in this document is derived from ARINC specification 620-7 (ARINC 620) (meteorological report version 1 thru 5). The ARINC 620 specification however is not superseded by this document.

Since most meteorological messages share a common approach to processing, triggering and transmitting data it is possible to use this specification in conjunction with other specifications. In particular, the ARINC 620 Meteorological Report specification is a recognized standard for AMDAR and it is therefore feasible and acceptable to specify that particular downlink format standard as an alternative to those specified within this document, although it is suggested that using the recommended message formats provided within the appendices to this specification will provide communications efficiency dividends over the ARINC 620-7 specified formats.

The following section describes the similarities and differences between the ARINC 620 meteorological report specification, specifically version 4 and 5, and AOSFRS (this document).

### **2.3.1 ARINC 620 versus this document**

Although a lot of commonalities exist between the ARINC 620 Meteorological Report and AOSFRS, there are some differences between the two. This paragraph may provide the reader a better understanding of those similarities and differences. It is important to remember that both specifications provide an accepted standard for AMDAR and the reader may choose between implementation of the AOSFRS or ARINC 620.

#### ***Data Acquisition***

Acquisition of data depends on the systems installed onboard and is independent of the specification. What matters for both specifications is that an interface exists to the best quality data source.

#### ***Data Handling***

ARINC 620 describes how to handle and derive parameters in notes that are presented with the down- and uplink formats. It does not specify how to detect and handle invalid data.

AOSFRS describes data handling, invalidation and derived parameters in a separate paragraph and, for optional parameters, in a separate appendix.

#### ***Phase of flight***

AOSFRS specifies conditions that determine the phase of flight for the weather message. ARINC 620 uses these phases of flight as well but other than for the time based scheme, does not provide clear conditions to determine these.

#### ***AMDAR observations***

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<sup>3</sup> EUMETNET AMDAR AAA AMDAR Software Developments – Technical Specification, Version 2, 1 August 2000.

<sup>4</sup> PROGRAM OPERATIONS AND STANDARDS OBSERVATIONS SPECIFICATION 2006-1, AMDAR AAA Version 3.0 Software Requirements Specification, 23 November 2006

Both specifications describe conditions when to trigger and store a meteorological observation. The conditions are the same in both specifications. ARINC 620 refers to phase of flight and series, where the term series refers to the observation contents and format for that particular phase of flight.

AOSFRS only refers to when an observation needs to be triggered and stored; the contents and format are dealt with separately and are independent of the phase of flight.

#### ***Message format***

ARINC620 provides specific downlink formats for each phase of flight (series). AOSFRS uses only one downlink format, regardless of the phase of flight.

ARINC 620 specifies 5 versions for the Meteorological Report to choose from. The message format and content depends on the version chosen and is largely fixed in terms of content and parameter composition, with unavailable parameters (e.g. water vapor is currently not available from the majority of AMDAR aircraft) transmitted as “blank space”. AOSFRS specifies one basic format as a minimum requirement and allows the addition of parameters in any sequence desired. The benefit of the latter is that communications costs can be reduced and minimized by transmitting required parameters and characters only. If only the most basic meteorological data were available or required, utilization of the AOSFRS format would require 40% less characters than ARINC 620 (version 5).

#### ***Message Transmission***

Both specifications specify messages to be transmitted to the ground as soon as they are complete. AOSFRS also specifies what to do with incomplete reports.

#### ***Software Configuration Control***

Both specifications provide information on how to configure the software so that reporting behavior can be altered. ARINC 620 specifies fixed uplink formats with all the necessary configuration parameters.

AOSFRS specifies the items that need to be configurable and does not provide a fixed format for uplinks. As an alternative to uplinks, AOSFRS specifies that the configuration can also be changed through flight deck interfaces and/or code changes. This allows for more flexibility for implementation of the specification within different avionics systems.

#### ***AMDAR Optimization Message***

Both specifications mention an AMDAR optimization message. ARINC620 refers to the contents of the configuration uplinks where in fact it is a downlink message telling the operator what aircraft is leaving a gate at airport X to fly to airport Y.

#### ***Configuration Message***

Both specifications describe a means to retrieve information on the status/contents for all configurable parameters; the information request and format differ.

#### ***Data Compression***

Both documents describe the same base-40 data compression technique.

## 2.4 Further Reading

A detailed description of the AMDAR system is given in the Aircraft Meteorological Data Relay (AMDAR) Reference Manual (WMO-No 958) available from the World Meteorological Organization, Geneva, Switzerland:

[http://www.wmo.int/amdar/Publications/AMDAR\\_Reference\\_Manual\\_2003.pdf](http://www.wmo.int/amdar/Publications/AMDAR_Reference_Manual_2003.pdf)

and in the WMO GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION, Part 2, Chapter 3, Aircraft Observations:

<http://www.wmo.int/pages/prog/www/IMOP/CIMO-Guide.html>



### 3 AMDAR Onboard Software Requirements

The primary functions of the AMDAR Onboard Software Process are to:

- Accept input data from a variety of the aircraft innate avionics equipment.
- Perform high level quality checks on the input data
- Perform calculations upon the input data to derive required meteorological parameters
- At set intervals, process collected data into standard output messages for transmission to ground stations and
- Accept inputs, allowing users to alter the AMDAR Onboard Software behavior.

Figure3 shows a high level schematic of the AMDAR onboard system. This chapter translates the functions represented in this schematic into functional requirements for the AMDAR onboard software.

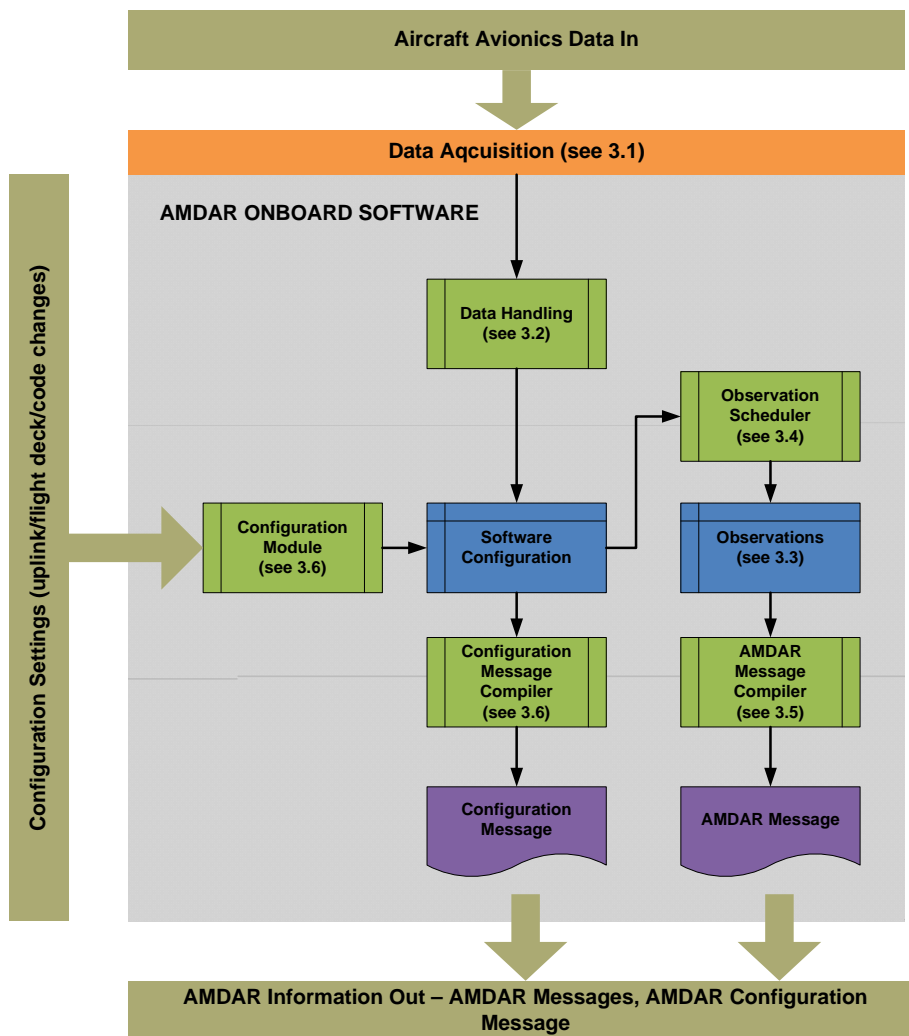


Figure3: AMDAR Onboard Component of the AMDAR System and the schematic functionality of the AMDAR Onboard Software.

### 3.1 Data Acquisition

The onboard Data Acquisition System (DAS) shall provide a data interface to the highest quality data sources available from the aircraft. In case the direct source is not available to the acquisition system it is acceptable to use an indirect source, as long as the quality of the data is maintained. For example, the latitude is derived from the inertial reference system but this source is not connected directly to the AOS. Latitude is however transmitted to the Flight Management Computer (FMC) and this source is available to the AOS. As long as data quality is maintained the latitude can be obtained from the FMC instead of directly from the Inertial Reference System (IRS).

The source data for meteorological observations require significant correction and complex processing to yield meteorological measurements that are representative of the free air-stream in the aircraft vicinity. A full description of all the processes involved is beyond the scope of this document. An outline of the principles and references for further reading are provided in the WMO Guide to Meteorological Instruments and Methods of Observation, , part II chapter three. ([ftp://ftp.wmo.int/Documents/MediaPublic/Publications/WMO8\\_CIMOguide/Part-II/WMO8\\_Ed2008\\_PartII\\_Ch3\\_Up2010\\_en.pdf](ftp://ftp.wmo.int/Documents/MediaPublic/Publications/WMO8_CIMOguide/Part-II/WMO8_Ed2008_PartII_Ch3_Up2010_en.pdf))

Figure2 in Section 2.2 shows schematically the principal data sources feeding into a Flight Management System and together forming the DAS. Note that the configurations and availability of systems varies widely between aircraft models and airline fleets.

The tables below provide the input signals to be acquired. Distinction is made between signals that shall be acquired (Table 1), should be acquired (Table 2) and signals that are optional (Table 3).

If any of the parameters in Table 1 are not able to be acquired or derived from an avionics system to the required performance specifications, then the AOS application would be deemed to not meet required standards and should not be implemented.

If the avionics system and the CPU allowance for the AOS make it permissible and possible, parameters in Table 2 and Table 3 may be implemented, assuming that the appropriate corresponding requirements for alteration to downlink format are implemented and that the format alteration is able to be recognized and decoded by a ground processing system. Such a requirement and its implementation would require the utilization of the recommended downlink format defined within Appendix A.

**Table 1: Input Signals - Required**

DESCRIPTION	UNIT	RESOLUTION	RANGE	ACQ RATE	
				PREFERRED	MAX
AIRCRAFT ID	INT	N/A	N/A	N/A	N/A
AIR/GROUND SWITCH OR WEIGHT ON WHEELS	DISCRETE	N/A	N/A	1HZ	1HZ
COMPUTED AIR SPEED	KN	1	0 TO 800	1HZ	2HZ
DATE - DAY	DAY OF MONTH	1	0 - 31	1HZ	4HZ
GMT - HOURS	HOURS	1	00 - 23	1HZ	2HZ
GMT - MINUTES	MINUTES	1	00 - 59	1HZ	2HZ
GMT - SECONDS	SECONDS	1	00 - 59	1HZ	2HZ
LATITUDE	DEGREES	0.002	90°S TO 90°N	1HZ	4HZ
LONGITUDE	DEGREES	0.002	180°E TO 180°W	1HZ	4HZ
PRESSURE ALTITUDE IN ICAO STANDARD ATMOSPHERE	FT	1	-1000 TO 50000	1HZ	2HZ
STATIC AIR TEMPERATURE	°C	0.1	-99.9 TO +99.9	1HZ	2HZ
STATIC PRESSURE <sup>1)</sup>	HPA (MBAR)	1	900 TO 1050	1HZ	1HZ
WIND DIRECTION TRUE	DEGREES	1	0 TO 359	1HZ	2HZ
WIND SPEED	KN	1	0 TO 800	1HZ	2HZ
ROLL ANGLE	DEGREES	1	-180 TO 180	1HZ	1HZ
PITCH ANGLE	DEGREES	1	-90 TO 90	1HZ	1HZ

**Note 1:** If static pressure is not available from the aircraft systems it can be calculated from pressure altitude

For PALT equal to or less than 36 089 ft., static pressure (SP) is related to PALT (ft) by the following expression:

$$SP (hPa) = 1013.25[1 - 10^{-6} \times 6.8756(PALT)]^{5.2559}$$

If PALT is greater than 36 089 ft, static pressure is given by:

$$SP (hPa) = 226.32 \exp(-((PALT-36089)/20805))$$

**Table 2: Input Signals - Recommended**

DESCRIPTION	UNIT	RESOLUTION	RANGE	ACQ RATE	
				PREFERRED	MAX
DEPARTURE STATION	CHAR	N/A	N/A	N/A	N/A
DESTINATION STATION	CHAR	N/A	N/A	N/A	N/A
VERTICAL SPEED <sup>2)</sup>	FT/MIN	1	-2000 TO 2000	1HZ	1HZ
GROSS WEIGHT	KG	1	N/A	1HZ	1HZ
VERTICAL ACCELERATION	G	0.001	-3 TO +6	8HZ	16HZ

**Note 2:** Vertical speed is used in phase of flight determination. Vertical speed may be derived from altitude rate of change

**Table 3: Input Signals - Optional**

DESCRIPTION	UNIT	RESOLUTION	RANGE	ACQ RATE	
				PREFERRED	MAX
WATER VAPOR DATA	NOTE 3			1Hz	4Hz
ICING DATA <sup>4)</sup>	DISCRETE	N/A	N/A	1Hz	4Hz
ANTI-ICE	DISCRETE	N/A	N/A	1Hz	1Hz
AIRCRAFT CONFIGURATION INDICATOR	DISCRETE	N/A	0 TO 15	1Hz	4Hz
FLAPS	DEGREES	1	0 TO 50	1Hz	4Hz
GEAR DOWN/UP	DISCRETE	N/A	N/A	1Hz	2Hz
GNSS ALTITUDE	FT	1	-1000 TO 50000	1Hz	1Hz
GROUNDSPEED	KN	1	0 TO 800	1Hz	2Hz
TRUE TRACK	DEGREES	0.1	0.0 TO 359.9	1Hz	2Hz
TRUE HEADING	DEGREES	0.1	0.0 TO 359.9	1Hz	2Hz
TRUE AIRSPEED	KN	1	0 TO 800	1Hz	2Hz

**Note 3:**

If available, water Vapor can be measured and reported either as mixing ratio or relative humidity, depending on the type of sensor employed. For more information see appendix C.2.

**Note 4:**

Icing will be reported as value 1 when the aircraft icing sensor indicates no ice accretion, as value 2 when the sensor indicates ice accretion is occurring, and as value 0 when the status of icing is not able to be determined (note requires separate system installed).

**Note 5:**

Aircraft Configuration Indicator is defined within section 3.2.4.5.

## 3.2 Data Handling

### 3.2.1 Data acquisition rate

Input data can be acquired at different acquisition rates. For instance, data can be acquired 8 times per second but it is also possible to have parameters acquired once every two or four seconds. Following rules describe how to handle acquisition rates.

1. For input data acquired once per second, no special rule applies.
2. For input data acquired more than once per second, the last valid sample within that second shall be used.
3. For input data acquired less than once per second, the last valid sample shall be used.

### 3.2.2 Data Validation

Input Data should only be used when:

1. It is validated using applicable avionics validation standards and,
2. It passes the out of Range check. Input data values should be checked against the range given in Table 1, Table 2 and Table 3. When the input data value falls outside this range it is considered invalid.

Data that is invalid shall not be used in any calculation. Observations shall continue but invalid data shall be either not reported, or masked as specified, usually with a solidi ('/').Some indication should be provided within AMDAR observations and reports when the parameters, particularly

meteorological parameters, have been invalidated as this helps NMHS AMDAR program managers determine the existence of possible onboard faults or systemic issues.

### 3.2.3 Data Smoothing

While previous specifications for the AOS have incorporated algorithms for smoothing or averaging data parameters, this practice is not recommended without clear scientifically based justification. Smoothing or averaging should not be implemented. Therefore, unless specifically stated, all reported parameter values shall be obtained or be calculated from the highest frequency instantaneous sample available from the relevant data bus, closest to the observation time and subject to the Data Validation requirements specified in section 3.2.2.

### 3.2.4 Derived Parameters

#### 3.2.4.1 Phase of Flight

AMDAR observation intervals should be linked to aircraft flight phase. The following phases of flight conditions should be recognized:

- a) Ground
- b) Ascent
- c) Level flight (or Cruise or En-route)
- d) Descent

An assessment of the Phase of Flight should be made at regular one second intervals. The aircraft will be considered to occupy one of the phases of flight at any time, but transition from one phase to another does not necessarily follow the order listed above, except that Phase Ascent shall always follow Phase Ground for 60 seconds minimum.

##### 3.2.4.1.1 Ground

The aircraft is considered on the ground when it is not in one of the reporting flight modes (ascent, en-route or descent). The aircraft is in ground phase when:

1. Computed Airspeed is equal to or less than 100 knots *or* Computed Airspeed data is invalid; *and*
2. Air/ground switch indicates ground *or* weight on wheels is true

During this phase the software is active and processes data but no observations are made.

##### 3.2.4.1.2 Ascent

The aircraft is in ascent when:

1. Computed Airspeed > 100 kn; *and*
2. Altitude Rate > +200 feet/min; *and*
3. a. Pressure based scheme: Pressure Altitude <= Top of Climb (see Table 9); *or*  
b. Time based scheme: Flight time since take-off <= Ascent Total Duration (see Table 9)

When Ascent follows the ground phase, Ascent shall be held for a minimum of 60 seconds.

##### 3.2.4.1.3 En-Route

The aircraft is in en-route when:

1. Computed Airspeed > 100 kn; *and*
2. a. Pressure based scheme: Pressure Altitude > Top of Climb (see Table 9); *or*  
 b. Time based scheme: Flight time since take-off > Ascent total duration (see Table 9)

#### 3.2.4.1.4 Descent

The aircraft is in descent when:

1. Computed Airspeed > 100 kn; *and*
2. Altitude Rate < -200 feet/min ; *and*
3. Pressure Altitude < Top of Descent (see Table 11)

#### 3.2.4.2 Turbulence Metric

A turbulence metric should be derived and reported within the AMDAR observation. Metrics that should be used are:

1. Eddy Dissipation Rate (EDR)*and/or*
2. Derived Equivalent Vertical Gust (DEVG)

EDR is the preferred metric to be reported by AMDAR and the AOS should incorporate the reporting of both a routine or “Heartbeat” EDR observation and also reporting of the 3 event-based observations that are “triggered” based on the EDR 1-minute variables.

This document does not specify the requirements for calculation and provision of the EDR 1-minute variables but relies on the specification referenced within Appendix C.1.2.

For details on EDR calculation and the AMDAR reporting algorithm, see Appendix C.1.2

For recommended reporting formats incorporating EDR see Appendix A.

For details on DEVG calculation see appendix C.1.1

#### 3.2.4.3 Water Vapor / Relative Humidity / Dew Point

Water Vapor/ Relative humidity or Dew Point data may be reported within the AMDAR observation. Details for this parameter can be found in appendix C.2

Note that this parameter requires an appropriate sensor to be installed on the aircraft

#### 3.2.4.4 Roll Angle Flag

A Roll Angle Flag should be reported within the AMDAR observation.

The flag is used in one of two modes:

*Mode 1:* either as a quality indicator for wind speed and direction based on the aircraft roll angle (RA) and pitch angle (PA) or,

*Mode 2:* to provide an indication of which range bin the aircraft roll angle value lies within.

In Mode 1, the Roll Angle Flag will take the value B, G or H, with the corresponding meaning provided in the table below.

In Mode 2, the Roll Angle Flag will take either the value H with the same meaning for Mode 1, or an integer value from 0 to 9.

Table 4: Roll Angle Flag values

ROLL ANGLE FLAG VALUE	MEANING	MODE
B	$ RA  \geq 5^\circ$ OR ( $ RA  \geq 3^\circ$ AND $ PA  \geq 3^\circ$ )	1
G	$ RA  < 5^\circ$ OR ( $ RA  < 3^\circ$ AND $ PA  < 3^\circ$ )	1
H	ROLL ANGLE UNAVAILABLE OR UNDEFINED	1 AND 2
0	$0^\circ \leq  RA  < 1^\circ$	2
1	$1^\circ \leq  RA  < 2^\circ$	2
2	$2^\circ \leq  RA  < 3^\circ$	2
3	$3^\circ \leq  RA  < 4^\circ$	2
4	$4^\circ \leq  RA  < 5^\circ$	2
5	$5^\circ \leq  RA  < 7^\circ$	2
6	$7^\circ \leq  RA  < 10^\circ$	2
7	$10^\circ \leq  RA  < 14^\circ$	2
8	$14^\circ \leq  RA  < 20^\circ$	2
9	$20^\circ \leq  RA $	2

### 3.2.4.5 Aircraft Configuration Indicator

A derived parameter representing the aircraft configuration status may be added to the meteorological observation data. When used, the parameter shall be assigned a value according to the configuration status of the aircraft as in the following table:

Table 5: Aircraft Configuration Indicator Values

VALUE	MEANING
0	CONFIGURATION UNDEFINED / NOT REPORTABLE
1	CLEAN CONFIGURATION, GEAR RETRACTED
2	FIRST POSITION OF FLAPS EXTENSION, GEAR RETRACTED
3	SECOND POSITION OF FLAPS EXTENSION, GEAR RETRACTED
4	THIRD POSITION OF FLAPS EXTENSION, GEAR RETRACTED
5 TO 7	RESERVED
8	ONLY LANDING GEAR DOWN AND IN PLACE
9	FIRST POSITION OF FLAPS EXTENSION + LANDING GEAR DOWN AND IN PLACE
10	SECOND POSITION OF FLAPS EXTENSION + LANDING GEAR DOWN AND IN PLACE
11	THIRD POSITION OF FLAPS EXTENSION + LANDING GEAR DOWN AND IN PLACE
12 TO 14	RESERVED
15	WEIGHT ON WHEELS = TRUE

### 3.3 AMDAR Observations

A crucial function of the AMDAR software is to trigger and store observations. An Observation is a single consistent set of (calculated) parameter values at a point in space and time.

Observations are made during following phases of flight only:

- Ascent
- En-route (or Cruise)
- Descent

Observations shall be made either:

- 1) When a pre-set static pressure level is reached (Pressure based scheme, default)
- 2) When a pre-set time period has elapsed (Time Based scheme)

The software shall be capable of switching between either scheme but only one scheme shall be active at any given time.

Observations shall be stored in a dedicated area of memory until required.

There are several types of AMDAR Observations defined that, when reported, shall be indicated and identifiable within AMDAR reports, see following page:

Following Observation Types are defined

ASCENT – INITIAL
ASCENT
ASCENT ROUTINE
EN-ROUTE
MAXIMUM WIND
DESCENT
DESCENT ROUTINE
EDR ROUTINE
TOUCH-DOWN

Regardless of observation type, the following elements should be reported and form the Basic Observation Sequence:



**Table 6: Basic Observation Sequence elements**

DESCRIPTION	UNIT	PRECISION	RANGE	NOTE
OBSERVATION TYPE INDICATOR	INT	N/A	0-9	
LATITUDE	DEGR	1	90°S TO 90°N	
LONGITUDE	DEGR	1	180°E TO 180°W	
DAY	DAY	1	1 TO 31	
TIME	HHMMSS	1 SEC	000000 TO 235959	
PRESSURE ALTITUDE	TENS OF FT	10	-100 TO 5000	
STATIC AIR TEMPERATURE	TENTHS OF DEGR C	0.1	-999 TO +999	
WIND DIRECTION	DEGR FROM TRUE NORTH	1	0 TO 360	
WIND SPEED	KN	1	0 TO 800	
ROLL ANGLE FLAG	CHAR	N/A	N/A	SEE PAR 3.2.4.4

Additional parameters can be added to these elements, depending on availability, necessity and system capability:

**Table 7: Additional Observation elements**

DESCRIPTION	UNITS	PRECISION	RANGE	NOTE
ROUTINE EDR	STRING	N/A	N/A	1
DEVG	MS <sup>-1</sup>	10	0 - 20	
TRUE AIRSPEED	KN	1	0 TO 800	
TRUE HEADING	TENTHS OF DEGR	0.1	0 TO 3599	
GNSS ALTITUDE	TENS OF FEET	10	-100 TO 5000	
ANTI-ICE	DIS	N/A	N/A	
A/C CONFIGURATION INDICATOR	N/A	N/A	N/A	SEE PAR 3.2.4.5
MASS MIXING RATIO	KG/KG	10 <sup>6</sup>	0 TO 1	SEE APPENDIX C.2.1
RELATIVE HUMIDITY	HUNDRETHS OF %	100	0 TO 10000	SEE APPENDIX C.2
ICING	DIS	N/A	N/A	

Note 1:

Contents of EDR as per NCAR specification (see appendix C.1.2.1)

Unless otherwise indicated, the values of the elements reported are the most recently acquired valid value (see section 3.2.2) at or nearest to the observation time.

### 3.3.1 Ascent Initial Observation

An Ascent Observation shall be stored at the time of the OFF event. The Ascent Initial Observation should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

### 3.3.2 Ascent Observations

Ascent observations are triggered and stored during the ascent phase of flight at a frequency that is dependent on the reporting scheme used (see section 3.4).

Ascent Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

### **3.3.3 Descent Observations**

Descent observations are triggered and stored during the descent phase of flight at a frequency that is dependent on the reporting scheme used (see section 3.4).

Descent observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

### **3.3.4 Routine Observations**

Routine Observations are made at set and configurable time intervals and, when enabled, should be made during all phases of flight.

Routine Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

#### ***3.3.4.1 Ascent Routine Observations***

Ascent Routine Observations are Routine Observations made at set time intervals during the ascent phase of flight. These observations may be configured to be reported only when a pressure-based reporting scheme is in use so as to ensure data is still collected at regular time intervals in the case where the aircraft levels off during ascent and static pressure triggering cannot be used since the static pressure does not change during level flight. It will also ensure that observations are taken if the aircraft does not reach the set altitude for top-of-climb.

Ascent Routine Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

#### ***3.3.4.2 En-route Routine Observations***

En-route Routine Observations are Routine Observations that are made at set time intervals during the En-route flight phase and are independent of whether the Pressure Based or Time Based scheme is utilized for the acquisition of Ascent and Descent Observations.

Routine Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

#### ***3.3.4.3 Descent Routine Observations***

Descent Routine observations are Routine Observations made at set time intervals during the descent phase of flight. These observations may be configured to be reported only when a pressure-based reporting scheme is in use so as to ensure data is still collected at regular time intervals in the case where the aircraft levels off during descent and static pressure triggering cannot be used since the static pressure does not change during level flight.

Descent Routine Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

#### ***3.3.4.4 Maximum Wind Observation***

The Maximum Wind Observation is a special AMDAR observation that is triggered to be reported when the highest wind speed measured between a sequential pair of routine observations meets the criteria below. This observation is required to aid in locating jet stream cores and should be made in en-route flight phase only. The Maximum wind is derived according to the following criteria:

1. Observations of wind speed maxima will only be reported when the ambient pressure is lower than 600 hPa, *and*
2. The aircraft is in en-route, *and*
3. The wind speed exceeds 60 knots absolute, *and*
4. The wind speed exceeds by 10 knots or more the value observed at the previous routine observation, *and*
5. The wind speed exceeds by 10 knots or more the value observed at the subsequent routine observation.

The Maximum Wind option provides an additional observation that is taken at the time of occurrence of the peak wind measurement.

The Maximum Wind Observation should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported at the time of the maximum wind measurement.

### **3.3.5 EDR Routine Observations**

Mean and peak turbulence intensity (EDR –eddy dissipation rate) is calculated for each minute in flight. At regular and configurable time intervals an observation is stored that consists of the normal observation parameters, any additional parameters to be reported, concatenated with the EDR variables.

For full details on EDR calculation and reporting see appendix C.1.2

EDR Routine Observations should be identified by the Observation Type Indicator.

### **3.3.6 Touch-down Observation**

The Touch-down Observation shall be stored at the time of the ON event.

Touch-down Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

## **3.4 Flight Phases and Reporting Schemes**

The frequency at which most AMDAR observations are made depends on the phase of flight the aircraft is in.

The figure below illustrates how AMDAR Onboard Software should differentiate between the various flight phases.

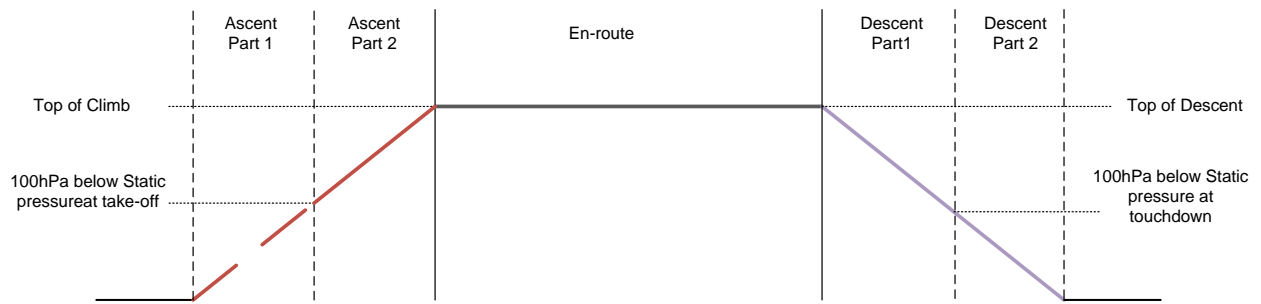


Figure 4: AMDAR flight phases

During the ascent and descent phases of flight, the triggering of Ascent and Descent Observations should be made based on either a Pressure Based Scheme or a Time Based Scheme as defined below.

The software may be capable of switching between either schemes but only one scheme shall be active at any given time.

Routine observations can also be made during both ascent and descent flight phases based on the pre-configured reporting frequency and should be triggered at set time intervals only. En-route Routine Observations should also be triggered at set time intervals and should begin at the conclusion of the ascent phase and terminate when reporting of Descent Observations begins.

The table below describes the observing frequencies for the various flight phases.

Table 8: AMDAR observing Interval by flight phase

	PRESSURE BASED SCHEME	TIME BASED SCHEME
<b>ASCENT PART 1</b>	5 OR 10 HPA INTERVALS FOR FIRST 100 HPA ( DEFAULT 10 HPA)	3 TO 20SECS INTERVALS (DEFAULT 6) FOR 30 TO 200SECS (DEFAULT 90)
<b>ASCENT PART 2</b>	25 OR 50 HPA INTERVALS ABOVE FIRST 100 HPA (DEFAULT 50 HPA)	20 TO 60SECS INTERVALS (DEFAULT 20) FOR 490 TO 1050SECS (DEFAULT 510)
<b>EN-ROUTE:</b>	1 TO 60 MINUTE INTERVALS (DEFAULT 7)	
<b>DESCENT PART 1</b>	25 OR 50 HPA INTERVALS FROM TOD TO LAST 100 HPA (DEFAULT 50 HPA)	20 TO 300SECS INTERVALS (DEFAULT 40) FROM TOP OF DESCENT TO TOUCHDOWN.
<b>DESCENT PART 2</b>	5 OR 10 HPA INTERVALS FOR LAST 100 HPA (DEFAULT 10 HPA)	

The paragraphs below provide detailed information on the content of Table 8.

### 3.4.1 Pressure Based Scheme

#### 3.4.1.1 Ascent

During the Ascent Flight Phase, Ascent Observations shall be made at defined Ambient Static Pressure levels which will be known as "Ascent Target Pressures". These will be referenced to the Ambient Pressure at take-off.

##### 3.4.1.1.1 Ambient Static Pressure at Take-Off

At the time of take-off, the Ambient Static Pressure shall be determined by noting the average value of p taken between the second successive measurement of the Computed Airspeed that exceeds 60

knots and the second successive measurement of the Computed Airspeed that exceeds 90 knots. The Ambient Static Pressure at take-off will be stored.

If the Computed Airspeed falls back below 60 knots before Ascent is entered, but after an Ambient Static Pressure at take-off value is stored, then the value stored shall be overwritten when the Computed Airspeed next increases from 60 through 90 knots.

#### 3.4.1.1.2 Initial Ascent Observation

An initial Ascent Observation shall be made and stored at the time of the OFF event (take-off).

#### 3.4.1.1.3 Ascent Part 1

Ascent Observations shall be made when the Ambient Static Pressure first falls below the Ascent Target Pressure. The first Ascent Target Pressure shall be the nearest multiple of 10 hPa (modifiable to 5hPa) below the Ambient Static Pressure at take-off. The next nine (modifiable to 19 if 5hPa is used) Ascent Target Pressures shall follow at 10 hPa (modifiable to 5hPa) intervals decrementing from the first Ascent Target Pressure level.

For interval and duration values see Table 9.

#### 3.4.1.1.4 Ascent Part 2

The eleventh (or twenty-first) Ascent Target Pressure shall be the nearest multiple of 50 hPa (modifiable to 25hPa) below the tenth (or twentieth) Ascent Target Pressure. The twelfth (or twenty-second) and subsequent Ascent Target Pressures shall follow at 50 hPa (modifiable to 25hPa) intervals decrementing from the eleventh (or twenty-first) Ascent Target Pressure. Observations will continue at 50 hPa (modifiable to 25hPa) intervals throughout the remainder of the Ascent Phase.

The complete Ascent data profile will thus consist of ten observations at 10 hPa (or twenty at 5 hPa) intervals over the first 100 hPa, and Observations at 50 hPa (or 25 hPa) intervals thereafter until the Ascent is complete.

For interval and duration values see Table 9.

#### 3.4.1.1.5 Ascent Routine Observations

Routine observations shall be made at set time intervals during flight phase ascent. The interval timer resets and commences following each observation. If no pressure level change is encountered during the preset time interval, an observation is triggered and the timer is reset. The time interval is the same as the en-route observation time interval (see Table 10)

### 3.4.1.2 Descent

During Phase of Flight Descent, Observations shall be made at defined Ambient Static Pressure levels, which will be known as "Descent Target Pressures".

The first Descent Target Pressure shall be the first multiple of 50 hPa (modifiable to 25hPa) above the pressure recorded when the Descent phase was established. Subsequent Descent Target Pressures shall be at 50 hPa (modifiable to 25hPa) intervals. Observations shall be made when the Ambient Static Pressure first rises above the Descent Target Pressure.

At and above 700 hPa the software shall, in addition to the continued formation of Observations at 50 hPa intervals, form Observations at 10 hPa intervals incrementing from 700 hPa. Only the ten

most recent Observations at 10 hPa intervals are retained. This additional sampling shall continue until the Descent is completed. In the event of the aircraft landing before a complete set of 50 hPa (modifiable to 25hPa) observations have been made the message will be padded out with the “/” character followed by a new message which contains the ten Observations made before touch-down. The complete set of Descent Observations is thus a series of observations at 50 hPa intervals, augmented by a detailed vertical survey of the last 100 hPa in 10 hPa increments, which shall not include repeats of observations at 50 hPa intervals.

For Top of Descent and interval values see Table 11.

#### 3.4.1.2.1 Touch-down Observation

The Touch-Down observation should be made and stored before and as close as possible to the time of the ON event.

Touch-down Observations should be identified by the Observation Type Indicator and shall consist of the Basic Observation Sequence and any additional parameters to be reported.

#### 3.4.1.2.2 Descent Routine Observations

Routine observations shall be made at set time intervals during flight phase descent. The interval timer resets and commences following each observation. If no pressure level change is encountered during the preset time interval, an observation is triggered and the timer is reset. The time interval is the same as the en-route observation time interval (see Table 10).

### 3.4.2 Time Based Scheme

#### 3.4.2.1 *Ascent*

##### 3.4.2.1.1 Initial Ascent Observation

An initial Ascent Observation is triggered at the “OFF” event.

##### 3.4.2.1.2 Part 1

Following the Initial observation, observations are accumulated at set time intervals until the part #1 duration limit is reached, counted from the “OFF” event. For interval and duration values see Table 9.

##### 3.4.2.1.3 Part 2

Observations are accumulated from the expiration of the Part #1 data acquisition period. Part #2 data observations are taken at set time intervals until the Ascent total duration limit is reached, counted from the “OFF” event. For interval and duration values see Table 9.

#### 3.4.2.2 *Descent*

Descent data measurements begin at Top of Descent and are accumulated at a set time interval. Top of Descent is modifiable.

For Top of Descent and interval values see Table 11.

#### 3.4.2.2.1 Touch-down Observation

An observation is stored as close as possible but before the aircraft touches down. This observation is included as the last observation in the last descent message.

### 3.5 Message Compilation

#### 3.5.1 Content

AMDAR Observations are collected and stored during flight. When a pre-set or maximum allowable number of observations are stored, a message shall be formed containing these observations. After a message is transmitted, the observations can be discarded. The message shall provide at least the following information:

- Identification as AMDAR data
- Software version indicator i.e. what specification it conforms to
- Reporting scheme (time-based or pressure-based)
- All required AMDAR Observations
- Any other information required to decode and reform data at the original and highest quality possible.

The AMDAR onboard system shall be capable of transmitting AMDAR Observations to the ground according to the Transmission Requirements below.

The AMDAR onboard system should be capable of transmitting the following messages:

- AMDAR Optimization
- AMDAR Status

#### 3.5.2 Format

The message format depends on the standard adopted. For AOSFRS (this document) see Appendix A.

##### 3.5.2.1 ACARS messages

When using ACARS, the AMDAR message format is bound to ACARS message protocol. This protocol does not impose any restrictions on the message format. For completeness a short description of the ACARS message block is provided below.

Most ACARS messages are only 100 to 200 characters in length. Such messages are made up of a one-block transmission from (or to) the aircraft. One ACARS block is constrained to be no more than 220 characters within the body of the message. For downlink messages which are longer than 220 characters, the ACARS unit splits the message into multiple blocks, transmitting each block to the Remote Ground Station (RGS). There is a constraint that no message may be made up of more than 16 blocks. The RGS collects each block of such multi-block messages until the complete message is received before processing and routing the message. ACARS also contains protocols to support a retry of failed messages.

#### 3.5.3 Transmission Requirements

The frequency of transmission of messages must take into account two factors:

1. It is critical to many meteorological applications, including weather forecasting and Numerical Weather Prediction that Observations are made available to NMHSs as close to “real-time” as possible, particularly for Ascent and Descent flight phases; and,
2. Communications costs, particularly for air to ground, are relatively expensive and, therefore, efficiency and economy in the content of messages is very important.

Taking these factors into account, the following requirements specifications are made.

The transmission of messages should be structured so as to ensure that Ascent and Descent Observations are available at the NMHS within 15 minutes.

Ideally, messages consisting solely of En-route should be transmitted so as to ensure availability at the NMHS within the minimum lapse time, taking into account communications costs, efficiency and other factors such as availability of communications relay stations.

Messages that contain critical observations that have been identified as requiring immediate transmission, for example, turbulence event based reports may require immediate transmission.

Regardless of the format, messages shall be sent to the ground as soon as they are complete via the most reliable and efficient means possible.

Even if the message transmission method is subject to message volume or size restrictions, as is the case for ACARS and the pre-set number of observations has not been reached, pending messages shall be sent immediately in situations outlined below:

1. Flight phase transitions. For example; the aircraft transitions from flight phase ascent to flight phase en-route, the pre-set number of observations is ten but only five observations are stored. In this case, a message shall be send with only five observations.
2. Reporting turned off by software control. For example; reporting during descent is turned on initially. During descent, reporting is switched off by uplink command. At that time only seven observations were stored. In this case, a message shall be sent with only seven observations. More information on software configuration control can be found in paragraph 3.6.



## 3.6 Software Configuration Control

The software shall be configurable to allow reporting behavior and AOS functionality to be altered. The actual triggering of observations depends on several parameters that are embedded in the software, many of which are configurable through an interface to the AMDAR software program. These parameters 'tell' the software when to report or not to report. Examples of such parameters are phase of flight, i.e. whether the aircraft is ascending, descending or in level flight pressure altitude, geographical position of the aircraft, i.e. observations are made only within or outside of predefined geographical locations, and time of day, i.e. reporting is only done within a defined time frame. By making these parameters configurable, the observing and reporting regime for AMDAR is able to be modified according to changing meteorological, programmatic or economic requirements.

Changes in configuration are established by any combination of the following methods (in order of preference):

1. Uplink commands
2. Manual entry through flight deck interface displays
3. Code changes

Apart from the Reporting On/Off switch (section 3.6.2.1 for specific requirements), changes to the configuration by one of the methods described above should become permanent until changed again. If for whatever reason the configuration settings are lost, the settings shall revert to a default configuration.

The specifications for uplink control message formats are not specified within this document as they will be avionics and communications system dependent. It is therefore recommended that, in support of utilization of software configuration control, the AOS applications developer should provide a full description and specification of the uplink command control system that is implemented.

### 3.6.1 Observation Frequency Control

Following tables describe the required observation frequency control parameters for Ascent, En-route, Descent and EDR routine observations.

**Table 9: Ascent observation control parameters**

CHARACTERS	DATA	DESCRIPTION	REMARKS
1	0 OR 1	PRESSURE BASED SCHEME (0) OR TIME BASED SCHEME (1)	DEFAULT = 0
2	SS	ASCENT PART 1 TIME INTERVAL (SECONDS)	TIME BASED SCHEME DEFAULT = 06 RANGE = 03-20
3	SSS	ASCENT PART 1 DURATION (SECONDS)	TIME BASED SCHEME DEFAULT = 090 RANGE = 030-200
2	SS	ASCENT PART 2 TIME INTERVAL (SECONDS)	TIME BASED SCHEME DEFAULT = 20 RANGE = 20-60
3	SSS	ASCENT TOTAL DURATION (SECONDSX10)	TIME BASED SCHEME DEFAULT = 051 RANGE = 051-111
2	NN	PART 1 PRESSURE INTERVAL (HPA)	PRESSURE BASED SCHEME DEFAULT = 10 RANGE = 1 TO 20
2	NN	NUMBER OF OBSERVATIONS MADE DURING ASCENT PART 1.	PRESSURE BASED SCHEME VALUE = 10 OR 20 DEFAULT = 10 NOTE: PART 1 PRESSURE INTERVAL X PART 1 NUMBER OF OBSERVATIONS MUST BE 100
2	NN	PART 2 PRESSURE INTERVAL (HPA)	PRESSURE BASED SCHEME DEFAULT = 50 RANGE = 20 TO 50
3	NNN	TOP OF CLIMB (x100FT)	DEFAULT = 200 RANGE = 150-350 <sup>1)</sup>
1	0 OR 1	ROUTINE OBSERVATIONS ENABLED (1) OR DISABLED (0)	DEFAULT = 1

Note 1: Default settings for the Top Of Climb must be chosen to match operational profiles of the aircraft type, i.e. they must be set lower than the common cruise altitude for the aircraft type the software will be installed on.

**Table 10: En-route observation control parameters**

CHARACTERS	DATA	DESCRIPTION	REMARKS
2	MM	OBSERVATION INTERVAL (MINUTES)	DEFAULT = 7 RANGE = 1-60
1	0 OR 1	ENABLE (1) OR DISABLE (0) MAXIMUM WIND REPORTING	DEFAULT = 1

**Table 11: Descent observation control parameters**

CHARACTERS	DATA	DESCRIPTION	REMARKS
1	0 OR 1	PRESSURE BASED SCHEME (0) OR TIME BASED SCHEME (1)	0 = DEFAULT
3	SSS	DESCENT TIME INTERVAL (SECONDS)	TIME BASED SCHEME DEFAULT = 040 RANGE = 010-300
2	NN	DESCENT PRESSURE INTERVAL (HPA)	PRESSURE BASED SCHEME VALUE = 25 OR 50 DEFAULT = 50
3	NNN	TOP OF DESCENT (x100FT)	DEFAULT = 200 RANGE = 150-350
1	0 OR 1	ROUTINE OBSERVATIONS ENABLED (1) OR DISABLED (0)	DEFAULT = 1

**Table 12: EDR Routine observation control parameters**

CHARACTERS	DATA	DESCRIPTION	REMARKS
1	0 OR 1	ROUTINE EDR OBSERVATIONS DISABLED (0) OR ENABLED (1)	0 = DEFAULT
2	MM	ROUTINE EDR TIME INTERVAL (MINUTES)	DEFAULT = 15 RANGE = 0 - 30

### 3.6.2 Reporting Control

#### 3.6.2.1 Reporting on/off

**Table13: AMDAR switch**

CHARACTERS	DATA	DESCRIPTION	REMARKS
1	N	REPORT ACTIVATION FLAG	0 = REPORTING OFF 1 = DESCENT PHASE ONLY ACTIVE 2 = EN-ROUTE PHASE ONLY ACTIVE 3 = EN-ROUTE & DESCENT PHASES ACTIVE 4 = ASCENT PHASE ONLY ACTIVE 5 = ASCENT & DESCENT PHASES ACTIVE 6 = ASCENT & EN ROUTE PHASES ACTIVE 7 = ALL FLIGHT PHASES ON (DEFAULT)

The following requirements relating to this configuration control are specified:

1. The default configuration setting is recommend to be “All flight phases on”, which ensures that AOS will be configured for reporting upon software activation or reset.
2. Ideally the AOS should support the functionality to modify the Reporting on/off configuration settings both permanently and also for a number (N = 1 to 99) of flights, after which the configuration reverts to the default setting.
3. If the AOS is not to be controlled by a ground-based AMDAR data optimization system, then changes to this configuration setting should be permanent.
4. If requirement 2 is not able to be met and the AOS is to be controlled by a ground-based AMDAR data optimization system, then changes to this configuration setting should not be

permanent and the switch should revert to the default setting at the conclusion of each flight. It should be understood that, unless this requirement is met, the optimization system will either need to keep track of the reporting status or else an uplink command must be sent in response to every flight notification.

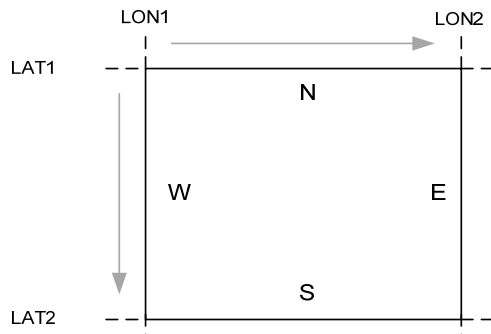
### 3.6.2.2 Geographical Control boxes

The AOS shall be configurable so that a minimum of 10 geographical boxes in which reporting is enabled or disabled. Outside these boxes reporting is disabled depending on the airport limitation (see paragraph 3.6.2.3).

A box is defined by setting two lateral and two longitudinal boundaries in degrees. When defining the boundaries, SOUTH and WEST are negative i.e. 20S is -20 and 40W is -040

The area will always be defined as that between LAT1 to LAT2 in a southerly direction, and LON1 to LON2 in an easterly direction (20N-80S, 120W-50E for example).

Figure 5: GEO box description



The order of priority for these boxes should be from 10 (or more if implemented) to 1, thus allowing a large area to be enabled for reporting using box 1 and a smaller region to be disabled within this box, using box 2 for example. Default settings are as follows:

Table 14: Geographical control box default settings

Box	LAT1	LAT2	LON1	LON2	STATUS
1	90	-90	180	-180	DISABLE REPORTING
2	90	-90	180	-180	DISABLE REPORTING
3	90	-90	180	-180	DISABLE REPORTING
4	90	-90	180	-180	DISABLE REPORTING
5	90	-90	180	-180	DISABLE REPORTING
6	90	-90	180	-180	DISABLE REPORTING
7	90	-90	180	-180	DISABLE REPORTING
8	90	-90	180	-180	DISABLE REPORTING
9	90	-90	180	-180	DISABLE REPORTING
10	90	-90	180	-180	ENABLE REPORTING

### 3.6.2.3 Airport specific reporting

The AOS should be configurable so that a minimum of 20 and up to 50 airports around which reporting for ascent, descent or both, can be enabled or disabled. The settings applied to these specific locations shall take priority over the geographical limiting function.

Each airport shall be described by its four letter ICAO airport designator. A flag is used to control whether observing during ascent, descent or both is activated or deactivated for this location. Following table shows the parameter configuration for the first airport. This is to be provided for the number of airports able to be configured.

**Table 15: Airport control parameters**

CHARACTERS	DATA	DESCRIPTION	REMARKS
4	I <sub>A</sub> I <sub>A</sub> I <sub>A</sub> I <sub>A</sub>	ICAO AIRPORT DESIGNATOR	"0000" = DEFAULT
1	F <sub>A</sub>	AIRPORT ACTIVATION FLAG	0 = ASCENT ON / DESCENT ON (DEFAULT) 1 = ASCENT ON / DESCENT OFF 2 = ASCENT OFF / DESCENT ON 3 = ASCENT OFF / DESCENT OFF

### 3.6.2.4 Time Limiting

It should be possible to configure a single time window during which reporting is inhibited. This setting has priority over all other settings except reporting off (see paragraph 3.6.2.1)

**Table 16: Time limit control parameters**

CHARACTERS	DATA	DESCRIPTION	REMARKS
4	H1H1H2H2	DISABLE OBSERVATIONS BETWEEN SELECTED HOURS (00-23) UTC, EVERY DAY	H1H1 = START OF INHIBIT PERIOD H2H2 = END OF INHIBIT PERIOD DEFAULT = 0000

The default value is interpreted as no interval selected and report though all 24 hour periods. The Inhibit Period starts at the first designated hour in the day and ends when the next designated hour is reached the same or next day. Thus 2301 means inhibit between 2300 hours and 0100 hours the next day, every day. (Two hours spanning midnight UTC).

### 3.6.2.5 EDR Event message settings

If EDR reporting is implemented, it should be possible to switch off EDR event reporting and alter the settings for the threshold values as per the table below:

**Table 17: EDR Event Message control parameters**

CHARACTERS	DATA	DESCRIPTION	REMARKS
1	0 OR 1	EDR EVENT MESSAGE DISABLED (0) OR ENABLED (1)	0 = DEFAULT
2	MM	EDR TYPE 1 EVENT THRESHOLD	DEFAULT = 0.18
2	MM	EDR TYPE 2 EVENT THRESHOLD	DEFAULT = 0.12
2	MM	EDR TYPE 3 EVENT THRESHOLD	DEFAULT = 0.06

## 3.6.3 Configuration Message

The software should provide for a message that lists the current settings for all of the control parameters mentioned in previous paragraph.

The message can be requested via either or both (in order of preference)

1. An uplink command.
2. Manual request through flight deck interface displays

For recommended contents and format of the Configuration Message, see Appendix B

#### **3.6.4 AMDAR Optimization Message**

An AMDAR optimization message may be sent to the NMHS and/or airline prior to departure of every flight. This message allows the NMHS and/or airline to alter the software configuration prior to flight and thereby manage data volumes and eliminate redundant observations and messages.

For example, an ascent profile is required for an airport only once per hour. But if during that hour more than one AMDAR equipped aircraft takes off, the system produces data that is not required. In order to prevent multiple aircraft sending AMDAR messages, a ground based system determines which aircraft to switch off by using the information in the optimization message.

The optimization message may be a standard OOOI message but should at least contain:

- Aircraft Identity
- Time Out (Parking brake released, all doors are closed.)
- DepartureAirport and ArrivalAirport
- Estimated time of departure from DepartureAirport
- Estimated time of arrival at DestinationAirport.

If implemented, the AMDAR Optimization Message production should be a configurable function of the AOS and, when activated, should be compiled and sent before Ascent at the earliest possible time after which the AOS has become active and the necessary parameters are available.

A recommended format for the optimization message can be found in Appendix B.2

## Appendix A AOSFRS message format for ACARS Version 01

### A.1 Introduction

This appendix specifies the AOSFRS message formats for utilization with the ACARS communications protocols. The AOSFRS message format provides a basic meteorological message with only the minimum amount of information that will still render a message useful as a meteorological message. At the same time it allows maximum flexibility to add information that enhances the basic report, if this information is required and available.

The reason for this approach is to allow the format to be used on a wide variety of aircraft/airlines where some may only have the basic information available, while others may be able to provide more information.

The AMDAR downlink message is set up in two sections:

1. A header block with information such as the AOSFRS message version and the aircraft identifier
2. A data block consisting of stored observations. For AOSFRS the data block consists of 8 stored observations. This number is chosen to stay within the transmission requirements mentioned in 3.5.3)

### A.2 Header Block

Each message shall have a header containing the information as described in the table below.

Table 18 : AOSFRS message header

LINE NUMBER	CHARACTER NUMBER	# OF CHAR	CONTENT	FORMAT	NOTES
1	1-3	3	AMDAR MESSAGE VERSION	"A01"	
2	1-26	1 TO 26	OPTIONAL PARAMETER INDICATION	# OR A THRU Z	SEE OPTIONAL PARAMETERS
3	1-6	6	AMDAR AIRCRAFT IDENTIFIER	AANNNN	1
3	7	1	NORMAL (N) OR COMPRESSED (C)	N OR C	2
3	8	1	TIME BASED (0) OR PRESSURE BASED SCHEME (1)	0 OR 1	
3	9-12	4	DEPARTUREAIRPORT	AAAA	3
3	13-16	4	ARRIVALAIRPORT	AAAA	3

#### Notes:

1. The AMDAR identifier is assigned by the requesting met office and should take the form AANNNN, where AA indicates the country of the AMDAR Program and NNNN is the unique identifier of the aircraft. To comply with the requirement not to disclose airline proprietary information, the aircraft call-sign should not be utilized or revealed within this identifier.
2. Normal means the data is not compressed. Compressed means the data is encoded using the compression scheme described in Appendix D.
3. Departure and Arrival airport are represented by their ICAO code. Reporting of these fields is optional but if available, strongly recommended.

### A.3 Data Block

The header shall be followed by the Data Block consisting of AMDAR Observations, with each observation on a new line. The observations shall contain the Basic Observation Sequence as described in Table 19. All parameters shall be right-justified.

#### A.3.1 Basic Observation Sequence

Table 19: AOSFRS Basic Observation Sequence format

CHARACTER NUMBER	# OF CHAR	CONTENT	FORMAT	NOTES	EXAMPLE
1	1	OBSERVATION TYPE INDICATOR	N	1	0
2-6	5	LATITUDE IN MINUTES	SNNNN	SOUTH IS NEGATIVE	-2976
7-12	6	LONGITUDE IN MINUTES	SNNNNN	WEST IS NEGATIVE	6081
13-19	7	DAY/TIME	NNNNNNN	2	879661
20-23	4	ALTITUDE IN TENS OF FEET	NNNN		3899
24-27	4	STATIC AIR TEMPERATURE TENTHS OF C	SNNN		-525
28-30	3	WIND DIRECTION	NNN		160
31-33	3	WIND SPEED	NNN		025
34	1	ROLL ANGLE FLAG	N	SEE PARAGRAPH 3.2.4.4	U

**Notes:**

1. Observation Type Indicator is indicated as follows:

OBSERVATION TYPE	OBSERVATION TYPE INDICATOR
ASCENT – INITIAL	0
ASCENT	1
ASCENT ROUTINE	2
EN-ROUTE	3
MAXIMUM WIND	4
DESCENT	5
DESCENT ROUTINE	6
EDR ROUTINE	7
TOUCH-DOWN	8

2. The day/time is presented as seconds into the month, and is calculated as follows:  
 $((\text{DATEDD}-1) * 86400) + (\text{GMT HH} * 3600) + (\text{GMT MM} * 60) + \text{GMT SS}$

*Example 1:*

An observation is made on July 1<sup>st</sup> at 20:53:22 UTC, the corresponding day/time will be  
 $((1-1)*86400) + (20*3600) + (53*60) + 22 = 75202$  seconds into the month

*Example 2:*

An observation is made on November 11th at 04:21:01 UTC, the corresponding day/time will be  
 $((11-1)*86400) + (4*3600) + (21*60) + 1 = 879661$  seconds into the month

#### A.3.2 Optional Parameters

The Basic Observation Sequence may be concatenated with optional parameters, if they are available. Optional parameters are assigned a Header Indicator (A, B, C etc.) This letter is used in the header to indicate that the observation sequence is followed by one or more optional parameters. For each optional parameter that is added to the observation sequence, the Header Indicator associated with the optional parameter shall be added in line 2 in the header. The sequence of the



letters determines the order in which the optional parameters are added. A # in line 2 indicates no additional parameters follow the basic observation sequence.

Optional parameters are described in Table 20 below. All parameters shall be right-justified.

**Table 20: AOSFRS Optional Parameters Format**

HEADER INDICATOR	# OF CHAR	CONTENT	FORMAT	NOTES	EXAMPLE
N/A	1 OR 9	ROUTINE EDR	C ORCNNNNNNNN	1	E12345678
A	3	DEVG	NNN		7
B	3	TRUE AIRSPEED	NNN		854
C	4	TRUE HEADING IN TENTHS OF DEGREES	NNNN		145
D		GNSS ALTITUDE	NNNN		3750
E	1	ANTI-ICE	N	2	1
F	2	A/C CONFIGURATION INDICATOR	NN	SEE PARAGRAPH 3.2.4.5	01
G	6	WATER VAPOR	NNNNNQ	SEE APPENDIX C.2	123450
H	6	RELATIVE HUMIDITY	NNNNNQ	SEE APPENDIX C.2	05000U
I	1	ICING	N	3	1

**Notes**

- EDR.  
No header indicator is assigned to routine EDR. When a routine EDR is triggered, an extra observation is inserted in the message containing the basic observation sequence plus any defined optional parameters, amended with the routine EDR value. To identify the observation as a routine EDR observation the Observation Type Indicator is set as per A.3.1 note 1. See example three below

The EDR event messages are separate messages (see paragraph A.4). For more information about EDR reporting behavior see paragraph C.1.2

- Anti-ice  
Anti-ice shall be reported using the following logic:  
1 = Anti-ice not activated  
2 = Anti-ice active  
/ = Anti-ice undetermined or invalid:

- Icing  
Icing will be reported as value 1 when the aircraft icing sensor indicates no ice accretion, as value 2 when the sensor indicates ice accretion is occurring, and as value 0 when the status of icing is not able to be determined (note requires separate system installed, move note to table 3 in CH3).

**Example 1**

A message with only the basic observation sequence would look as follows:

```
A01
#
AZ0001N1EHAMKJFK
0-2976 6081 8796613899-525160 25U
1-2976 6081 8796613899-525160 25U
```

```
1-2976 6081 8796613899-525160 25U
1-2976 6081 8796613899-525160 25U
1-2976 6081 8796613899-525160 25U
1-2976 6081 8796613899-525160 25U
1-2976 6081 8796613899-525160 25U
1-2976 6081 8796613899-525160 25U
```

This indicates that the observations in the message are basic observations only, aircraft AZ0001 is flying from Amsterdam to New York, the data is not compressed and the observations in ascent and descent are based on the pressure scheme.

Example 2:

GNSS and Anti-ice are available and are added to the basic observation sequence. A message would then look as follows

```
A01
DE
AZ0001N1EHAMKJFK
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
1-2976 6081 8796613899-525160 25U38540
```

This indicates that the observations in the message are basic observations amended with GNSS and Anti-ice information, aircraft AZ0001 is flying from Amsterdam to New York, the data is not compressed and the observations in ascent and descent are based on the pressure scheme.

Example 3:

Water Vapor, True Airspeed, Anti-ice, A/C config are available and added to the basic observation sequence, in that order. EDR is also available. When a routine EDR is triggered, an extra observation is inserted in the message containing the basic observation sequence plus any defined optional parameters, amended with the routine EDR value. To identify the extra observation as a routine EDR observation the Observation Type Indicator for that observation is set to 'B'.

A message would look like:

```
A01
GBEF
NL0032NOWMKKYMML
1-2976 6081 8796613899-525160 25U123450854101
7-2976 6081 8796613899-525160 25U123450854101E123456781)
1-2976 6081 8796613899-525160 25U123450854101
1-2976 6081 8796613899-525160 25U123450854101
3-2976 6081 8796613899-525160 25U123450854101
7-2976 6081 8796613899-525160 25U123450854101E123456781)
3-2976 6081 8796613899-525160 25U123450854101
3-2976 6081 8796613899-525160 25U123450854101
```

<sup>1)</sup> Routine EDR observation

This indicates that the observations in the message are basic observations amended with Water Vapor, True Airspeed, Anti-ice, A/C configuration, aircraft NL0032 is flying from Kuala Lumpur to Melbourne, the data is not compressed and the observations in ascent and descent are based on the time based scheme.

The data is interspersed with routine EDR observations, indicated by '7' in the Observation Type Indicator field.

## A.4 EDR Event Message

EDR event messages are generated when the peak or mean EDR exceeds pre-determined thresholds. For the triggering logic see paragraph C.1.2.2. The layout for the EDR event messages is described below.

**Table 21 : EDR event message header**

LINE NUMBER	CHARACTER NUMBER	# OF CHAR	CONTENT	FORMAT	NOTES
1	1-3	3	EDR EVENT MESSAGE VERSION	"EDR01"	
2	1-2	2	EDR EVENT TYPE INDICATION	AA	1
2	3	0 OR 1	FOLLOW UP REPORT	A	2
3	1-7	8	AMDAR AIRCRAFT IDENTIFIER	AAAAAAAA	3
3	8	1	NORMAL (N) OR COMPRESSED (C)	N OR C	4
3	9	1	TIME BASED (0) OR PRESSURE BASED SCHEME (1)	0 OR 1	
3	10-13	4	DEPARTUREAIRPORT	AAAA	5
3	14-17	4	ARRIVALAIRPORT	AAAA	5

**Notes:**

1. T1 for type 1, T2 for type 2, T3 for type 3
2. 'F' if the report is a follow-up report
3. The AMDAR identifier is assigned by the requesting NMHS.
4. Normal means the data is not compressed. Compressed means the data is encoded using the compression scheme described in Appendix D.
5. Departure and Arrival airport are represented by their ICAO code. Reporting of these fields is optional but if available, strongly recommended.

**Table 22: EDR Observation format**

CHARACTER NUMBER	# OF CHAR	CONTENT	FORMAT	NOTES	EXAMPLE
1	1	PHASE OF FLIGHT INDICATOR	A	1	R
2-6	5	LATITUDE IN MINUTES	SNNNN	SOUTH IS NEGATIVE	-2976
7-12	6	LONGITUDE IN MINUTES	SNNNNN	WEST IS NEGATIVE	6081
13-19	7	DAY/TIME	NNNNNNN	2	879661
20-23	4	ALTITUDE IN TENS OF FEET	NNNN		3899
24-27	4	STATIC AIR TEMPERATURE TENTHS OF C	SNNN		-525
28-30	3	WIND DIRECTION	NNN		160
31-33	3	WIND SPEED	NNN		025
34	1	ROLL ANGLE FLAG	N	SEE PARAGRAPH 3.2.4.4	U
35-43	9	EDR	CNNNNNNN		E12345678

1. Observation Type Indicator is indicated as follows:

OBSERVATION TYPE	OBSERVATION TYPE INDICATOR
ASCENT – INITIAL	0
ASCENT	1
ASCENT ROUTINE	2
EN-ROUTE	3
MAXIMUM WIND	4
DESCENT	5
DESCENT ROUTINE	6
EDR ROUTINE	7
TOUCH-DOWN	8

2. The day/time is presented as seconds into the month, and is calculated as follows:  
 $((\text{DATEDD}-1) * 86400) + (\text{GMT HH} * 3600) + (\text{GMT MM} * 60) + \text{GMT SS}$

*Example 1:*

An observation is made on July 1<sup>st</sup> at 20:53:22 UTC, the corresponding day/time will be  $((1-1)*86400) + (20*3600) + (53*60) + 22 = 75202$  seconds into the month

*Example 2:*

An observation is made on November 11th at 04:21:01 UTC, the corresponding day/time will be  $((11-1)*86400) + (4*3600) + (21*60) + 1 = 879661$  seconds into the month

Examples:

- 1) Type 1 event, 3 EDR measurements in buffer, follow-up report

```
EDR01
T1
AZ0001N1EHAMKJFK
1-2976 6081 8796613899-525160 25UE12345678
1-2976 6081 8796613899-525160 25UE12345678
1-2976 6081 8796613899-525160 25UE12345678
```

```
EDR01
T1F
AZ0001N1EHAMKJFK
1-2976 6081 8796613899-525160 25UE12345678
1-2976 6081 8796613899-525160 25UE12345678
1-2976 6081 8796613899-525160 25UE12345678
1-2976 6081 8796613899-525160 25UE12345678
1-2976 6081 8796613899-525160 25UE12345678
1-2976 6081 8796613899-525160 25UE12345678
```

- 2) Type 3 event, no follow up report

EDR01

T3

AZ0001N1EHAMKJFK

1-2976	6081	8796613899-525160	25UE12345678
1-2976	6081	8796613899-525160	25UE12345678
1-2976	6081	8796613899-525160	25UE12345678
1-2976	6081	8796613899-525160	25UE12345678
1-2976	6081	8796613899-525160	25UE12345678
1-2976	6081	8796613899-525160	25UE12345678

## Appendix B Additional AOSFRS Downlink Messages

### B.1 AOSFRS Configuration Message

A configuration message can be requested to allow a user to check the current status of the configuration parameters used by the AOS. The configuration message is only required when it can actually be retrieved from the aircraft somehow. A detailed description is given below.

#### SA01

```

IA.....IA DDDDAAAA SpAsIphAaG:lsgA:lsaT:lst
AIntA1/N/IntA2 RIntR DIntD1/IntD2
TOCTL1 TODTL2 H1H2H3H4
BBN LatY1/LatY2 LongX1/LongX2 SB BBN LatY1/LatY2 LongX1/LongX2 SB
BBN LatY1/LatY2 LongX1/LongX2 SB BBN LatY1/LatY2 LongX1/LongX2 SB
BBN LatY1/LatY2 LongX1/LongX2 SB BBN LatY1/LatY2 LongX1/LongX2 SB
BBN LatY1/LatY2 LongX1/LongX2 SB BBN LatY1/LatY2 LongX1/LongX2 SB
BBN LatY1/LatY2 LongX1/LongX2 SB BBN LatY1/LatY2 LongX1/LongX2 SB
A1ICAON A /S A5ICAON A /S A9ICAON A /S A13ICAON A /S A17ICAON A /S
A2ICAON A /S A6ICAON A /S A10ICAON A /S A14ICAON A /S A18ICAON A /S
A3ICAON A /S A7ICAON A /S A11ICAON A /S A15ICAON A /S A19ICAON A /S
A4ICAON A /S A8ICAON A /S A12ICAON A /S A16ICAON A /S A20ICAON A /S
    
```

The Bold and “/” characters are fixed characters.

Table 23: AOSFRS configuration message contents

PARAMETER	DESCRIPTION	FORMAT	NOTES	EXAMPLE
SA01	STATUS FOR AOSFRS MESSAGE VERSION	AAAA		SA04
I <sub>A</sub> .....I <sub>A</sub>	AMDAR AIRCRAFT IDENTIFIER (MAX6 CHARACTERS)	AANNNN		AU0013
DDDD	DEPARTURE AIRPORT	AAAA	ICAO CODE	EHAM
AAAA	ARRIVAL AIRPORT	AAAA	ICAO CODE	KJFK
S <sub>p</sub>	PRESSURE BASED (P) OR TIME BASED (T) SCHEME	A		P
A <sub>s</sub>	AMDAR SWITCH SETTING	N		7
I <sub>PH</sub>	FLIGHT PHASE AT TIME OF REQUEST	A	1	A
A <sub>a</sub>	AMDAR ACTIVE AT TIME OF REQUEST (Y/N)	A	2	Y
I <sub>SG</sub>	GEOGRAPHICAL IN RANGE AT TIME OF REQUEST Y/N	A		N
I <sub>SA</sub>	AIRPORT ACTIVE AT TIME OF REQUEST Y/N	A		Y
I <sub>ST</sub>	TIME WINDOW ACTIVE AT TIME OF REQUEST	A		Y
INT <sub>A1</sub>	OBSERVING INTERVAL DURING ASCENT PART 1, IN HPA OR SECONDS	NN		10
N	NUMBER OF OBSERVATIONS MADE DURING ASCENT PART 1	NN		10
INT <sub>A2</sub>	OBSERVING INTERVAL DURING ASCENT PART 2, IN HPA OR SECONDS	NN		50
INT <sub>R</sub>	OBSERVING INTERVAL DURING LEVEL FLIGHT IN SECONDS	NNN		420
INT <sub>D1</sub>	OBSERVING INTERVAL DURING DESCENT PART 1, IN HPA OR SECONDS	NN		50
INT <sub>D2</sub>	OBSERVING INTERVAL DURING DESCENT PART 2, IN HPA	NN		10
T <sub>L1</sub>	TOP OF CLIMB SETTING IN THOUSANDS OF FEET	NNNN		2000
T <sub>L2</sub>	TOP OF DESCENT SETTING IN THOUSANDS OF FEET	NNNN		2000

H <sub>1</sub> H <sub>2</sub> H <sub>3</sub> H <sub>4</sub>	TIME WINDOW SETTING	NNNN		0000
B <sub>N</sub>	GEOGRAPHICAL BOX NUMBER (0 TO 9)	N		1
LAT <sub>Y1</sub>	LATITUDE VALUE Y1 APPLIED TO BOX B <sub>N</sub> IN DEGREES	SNN		30
LAT <sub>Y2</sub>	LATITUDE VALUE Y2 APPLIED TO BOX B <sub>N</sub> IN DEGREES	SNN		-50
LONG <sub>X1</sub>	LONGITUDE VALUE X1 APPLIED TO BOX B <sub>N</sub> IN DEGREES	SNNN		-40
LONG <sub>X2</sub>	LONGITUDE VALUE X2 APPLIED TO BOX B <sub>N</sub> IN DEGREES	SNNN		120
S <sub>B</sub>	STATUS OF BOX B <sub>N</sub> (1 = REPORTING ACTIVE, 0 = REPORTING DISABLED)	N		1
ICAO <sub>N</sub>	ICAO CODE OF AIRPORT NUMBER A <sub>N</sub>	AAAA		EHAM
S <sub>A</sub>	STATUS OF AIRPORT (1 = REPORTING ACTIVE, 0 = REPORTING DISABLED)	N		1

**Notes :**

- Flight phase characters
  - G = Ground
  - A = Ascent
  - R = En-route
  - D = Descent
- AMDAR active shows if AMDAR is reporting, as follows
  - Y = AMDAR is active
  - N = AMDAR is inactive

Message Example

```

SA01
AU0113 EHAMKJFK P 7 A Y G:0 A:1 T:1
A10/10/50R420 D50/10
TOC 20TOD20 0000
B060/ 20 -100/ 601 B5 0/ 0 0/ 0 0
B1 0/ 0 0/ 0 0B6 0/ 0 0/ 0 0
B2 0/ 0 0/ 0 0B7 0/ 0 0/ 0 0
B3 0/ 0 0/ 0 0B8 0/ 0 0/ 0 0
B4 0/ 0 0/ 0 0B9 0/ 0 0/ 0 0
A1 EHAM/1A5 0000/0 A9 0000/0 A130000/0A170000/0
A2KJFK/0 A6 0000/0 A100000/0 A140000/0A180000/0
A3 0000/0 A7 0000/0 A110000/0 A150000/0A190000/0
A4 0000/0 A8 0000/0 A120000/0 A160000/0A200000/0

```



## B.2 AOSFRS Optimization Message

The format for the AOSFRS optimization message is as follows

CHARACTER NUMBER	# OF CHAR	CONTENT	FORMAT	NOTES	EXAMPLE
1-6	6	REPORT TYPE INDICATOR	NNNNNN	"A01OUT"	A01OUT
7-12	6	AMDAR AIRCRAFT IDENTIFIER	AANNNN	1	AU0022
13-14	2	DATE OUT	DD	DAY OF MONTH	10
15-18	4	GMT TIME OUT	HHMM		1623
19-22	4	DEPARTUREAIRPORT	AAAA		6081
23-26	4	ARRIVALAIRPORT	AAAA		879661
27-28	2	DATE ETA	DD	DAY OF MONTH	11
29-32	4	GMT ETA	HHMM		3899
33-34	2	DATE ESTIMATED OFF	DD	DAY OF MONTH ; 2	10
35-38	4	GMT ESTIMATED OFF TIME	HHMM	2	-525

1. The AMDAR identifier is assigned by the requesting NMHS and should take the form AANNNN, where AA indicates the country of the AMDAR Program and NNNN is the unique identifier of the aircraft. To comply with the requirement not to disclose airline proprietary information, the aircraft call-sign should not be utilized or revealed within this identifier.
2. Estimated off date and time when available

Example

A01OUTAU0022101623EHAMKLAX110315101650

Aircraft AU0022 has parking brakes off and all doors closed on day 10 at 16:23 GMT, departure station is Amsterdam flying to Los Angeles, estimated arrival time is on day 11 at 03:15 GMT, estimated off time is on day 10 at 16:50 GMT

## Appendix C Optional Derived Parameters

This appendix describes the derivation for parameters that are not part of the basic observation sequence.

### C.1 Turbulence

#### C.1.1 Derived Equivalent Vertical Gust (DEVG)

The Derived Equivalent Vertical Gust Velocity (DEVG) is a turbulence indicator defined as the instantaneous vertical gust velocity which, superimposed on a steady horizontal wind, would produce the measured acceleration of the aircraft. The effect of a gust on an aircraft depends on the mass and other characteristics, but these can be taken into account so that a gust velocity can be calculated which is independent of the aircraft.

The information below is an extract from the Australian Department of Defence, Structures Report 418, "The Australian Implementation of AMDAR/ACARS and the use of Derived Equivalent Gust Velocity as a Turbulence Indicator", Douglas J. Sherman, 1985.

The velocity of the derived equivalent vertical gust,  $U_{de}$ , (in tenths of meters per second) may be calculated by the formula:

$$DEVG = \frac{10Am|\Delta n|}{V}$$

Where  $|\Delta n|$  = peak modulus value of deviation of aircraft normal acceleration from 1g in units of g.

m = total aircraft mass in (metric) tonnes

V = calibrated airspeed at the time of occurrence of the acceleration peak, in knots.

A = An aircraft specific parameter which varies with flight conditions, and may be approximated by the following formulae:

$$A = \bar{A} + c_4(\bar{A} - c_5)\left(\frac{m}{\bar{m}} - 1\right)$$

$$\bar{A} = c_1 + \frac{c_2}{c_3 + H(kft)}$$

= Value of A when mass of aircraft equals reference mass

H = altitude in thousands of feet

$\bar{m}$  = Reference mass of aircraft in (metric) tonnes

The parameters  $c_1, c_2, K, c_5$  depend on the aircraft's typical flight profile. For various aircraft, the appropriate constants, based on the flight profiles indicated, are shown in Table 24.

Table24 : DEVG aircraft constants

Aircraft	$V_1$ knot	$V_c$ knot	$M_c$ Mach	$h_1$ ft	$h_c$ ft	$\bar{m}$ Tonne	$c_1$	$c_2$	$c_3$	$c_4$	$c_5$
A300B4	130	300	0.78	5000	30000	120	0.971	2690	79	0.49	19.6
A310	130	300	0.78	5000	35000	120	19.6	574	32	0.52	23.5
A318	120	300	0.78	5000	35000	40	34.7	878	28	0.52	40.3
A319	120	300	0.78	5000	35000	50	33.9	846	29	0.45	39.6
A320-200	120	300	0.78	5000	35000	55	35.9	771	27	0.44	40.7
A321	120	300	0.78	5000	35000	60	34.8	716	28	0.41	39.3
A330-200	120	300	0.82	5000	35000	170	5.88	1010	55	0.44	13.7
A330-300	120	300	0.82	5000	35000	170	5.89	1010	54	0.44	13.6
A340-200	120	300	0.82	5000	35000	190	6.36	949	54	0.41	13.7
A340-300	120	300	0.82	5000	35000	190	6.34	948	54	0.41	13.6
B727	120	300	0.84	5000	30000	50	6.45	4580	83	0.54	37.3
B737-200	120	300	0.73	3000	35000	30	62.0	351	14	0.64	59.4
B737-300	120	300	0.73	3000	35000	40	56.4	328	15	0.56	54.7
B737-400	120	300	0.73	3000	35000	40	56.3	329	15	0.56	54.5
B737-500	120	300	0.75	3000	35000	40	56.4	303	14	0.57	54.3
B737-600	120	300	0.78	3000	35000	40	45.4	420	18	0.57	45.3
B737-700	120	300	0.78	3000	35000	50	42.4	374	19	0.54	42.4
B737-800	120	300	0.78	3000	35000	50	42.2	350	18	0.57	41.9
B747-200	140	300	0.85	5000	40000	250	-2.41	2230	97	0.65	11.5
B747-300	140	300	0.85	5000	40000	200	2.27	1630	81	0.69	13.3
B747-400	140	300	0.85	5000	40000	250	-7.78	3260	120	0.62	10.2
B747SP	140	300	0.85	5000	40000	250	7.44	644	48	0.74	12.4
B757-200	140	300	0.8	3000	40000	100	29.2	298	22	0.55	30
B757-300	140	300	0.8	3000	40000	100	28.9	292	21	0.55	29.7
B767-200	140	300	0.8	3000	40000	110	12.8	918	46	0.65	19.8
B767-300	140	300	0.8	3000	40000	100	13.1	821	42	0.69	19.4
B767-400	140	300	0.8	3000	40000	150	12.9	701	45	0.54	18.3
B777-200	140	300	0.82	3000	40000	170	12.6	198	21	0.72	13.0
B777-300	140	300	0.82	3000	40000	210	13.1	147	19	0.65	12.9
BAC111-200	120	280	0.7	3000	30000	30	55.8	924	27	0.54	60.1
BAC111-475	120	280	0.7	3000	30000	30	50.6	930	28	0.54	55.3
DC10-30	150	300	0.82	5000	30000	200	-6.45	4080	130	0.56	15.0
Electra	100	350	0.7	5000	30000	30	48.9	220	9.1	0.57	41.2
Fokker-100	130	280	0.7	3000	30000	35	52.9	917	27	0.52	57.2
KingAir 100	110	200	0.6	9000	25000	3	70.6	2280	89	0.74	223.
L1011-500	120	300	0.83	5000	35000	150	11.7	712	47	0.59	17.1

## C.1.2 Eddy Dissipation Rate (EDR)

EDR is the preferred metric to be reported by AMDAR and the AOS should incorporate the reporting of both a routine or “Heartbeat” EDR observation and also reporting of the 3 event-based observations that are “triggered” based on the EDR 1-minute variables and as described below.

### C.1.2.1 EDR Calculations Algorithm

The EDR calculations algorithm calculates mean and peak turbulence intensity (EDR –eddy dissipation rate) for each minute in flight.

This document does not specify the requirements for calculation and provision of the EDR 1-minute metrics but relies on the specification provided by The National Center for Atmospheric Research (NCAR), see [http://www.ral.ucar.edu/projects/in\\_situ\\_software/](http://www.ral.ucar.edu/projects/in_situ_software/)

For AMDAR EDR reporting, the AOS requires and expects to interface with the external NCAR software package that provides the EDR 1-minute variables to the AOS application, which can then be utilized within the EDR reporting algorithm as defined below in C.1.2.2.

### C.1.2.2 EDR Reporting Algorithm

EDR reporting is based on event-triggered logic in combination with routine EDR observations. When an “event” is identified, the logic triggers the downlink of a message. Routine observations are incorporated in the normal AMDAR message.

Events are of 3 types:

- Type 1 (T1): peak EDR  $\geq$  T1 from the last minute.
- Type 2 (T2): peak EDR  $\geq$  T2 for at least 3 out of the last 6 minutes.
- Type 3 (T3): mean EDR  $\geq$  T3 for at least 4 out of the last 6 minutes.

Because it is important to know that the algorithm is working properly and there is *no* turbulence, routine observations are triggered at a specific time interval. These observations are known as Routine EDR observations. These routine observations are also triggered at takeoff and landing.

Based on the above there are 4 tunable parameters: the three thresholds (T1, T2 and T3), and the time interval between routine observations (HB). Default values for these parameters are:

- T1 = 0.18 peak EDR
- T2 = 0.12 peak EDR
- T3 = 0.06 mean EDR
- HB = 15 minutes.

Every minute a mean and peak EDR is generated by the Turbulence Algorithm. The following logic is used to determine *when* to generate and downlink a report:

Terminology:

- EDR Observation: an observation that includes the basic observation sequence concatenated with peak and mean EDR for a one minute period.

- EDR Event Report: between one and NM EDR observations are down-linked in an Event EDR Report. The EDR Event Report format is specified in paragraph A.4.

Thresholds and constants are set as follows:

- Threshold 1 = 0.18 peak EDR
- Threshold 2 = 0.12 peak EDR
- Threshold 3 = 0.06 mean EDR
- N = 3
- NP = 6
- M = 4
- NM = 6
- RR (minutes) = 15

The algorithm starts by putting EDR measurements into a buffer. The buffer has a maximum of NM measurements.

There are three types of threshold triggers, a follow-up trigger, and a routine report trigger:

1. A type 1 report is immediately generated if the latest peak EDR value is above Threshold 1.
2. A type 2 report is generated if (1) is not satisfied and N of the latest NP peak EDRs are above Threshold 2.
3. A type 3 report is generated if (1) and (2) are not satisfied and M of the latest NM mean EDRs are above Threshold 3.
4. A follow-up report is generated if exactly NP minutes (measurements) have passed since a type 1 or type 2 report.
5. A routine observation is generated if exactly RR minutes have passed since the last routine report (of any type). Additionally, a routine observation is always generated at the beginning (1 minute after the turbulence code startup) and at the end of every flight (triggered when the wheels touch down)<sup>1</sup>. Routine measurements are interspersed with the normal AMDAR observations see A.3.2, Table 20, note 1.

<sup>1</sup> when activated, the routine observation generated at the end of flight (ON event) is to be stored and reported separately from the Touch-down Observation (see paragraph 3.3.6)

Remarks:

- Threshold 1 > Threshold 2 > Threshold 3
- $NM \geq NP$
- Measurements are only reported if they have not been already **except** for measurements reported in routine reports.
- The buffer is cleared after a type 1 or type 2 report, but it is not cleared after type 3, follow-up, or routine reports.
- A type 1 report can have 1 to NP measurements.
- A type 2 report can only occur if there are exactly NP measurements in the buffer.
- A type 3 report can only occur if there are at least NM measurements in the buffer. It has minimum length of NP (and thus the number of measurements is between NP and NM, inclusive).
- A follow-up report has NP measurements.
- A routine report has one measurement

See next page for the reporting logic flowchart.

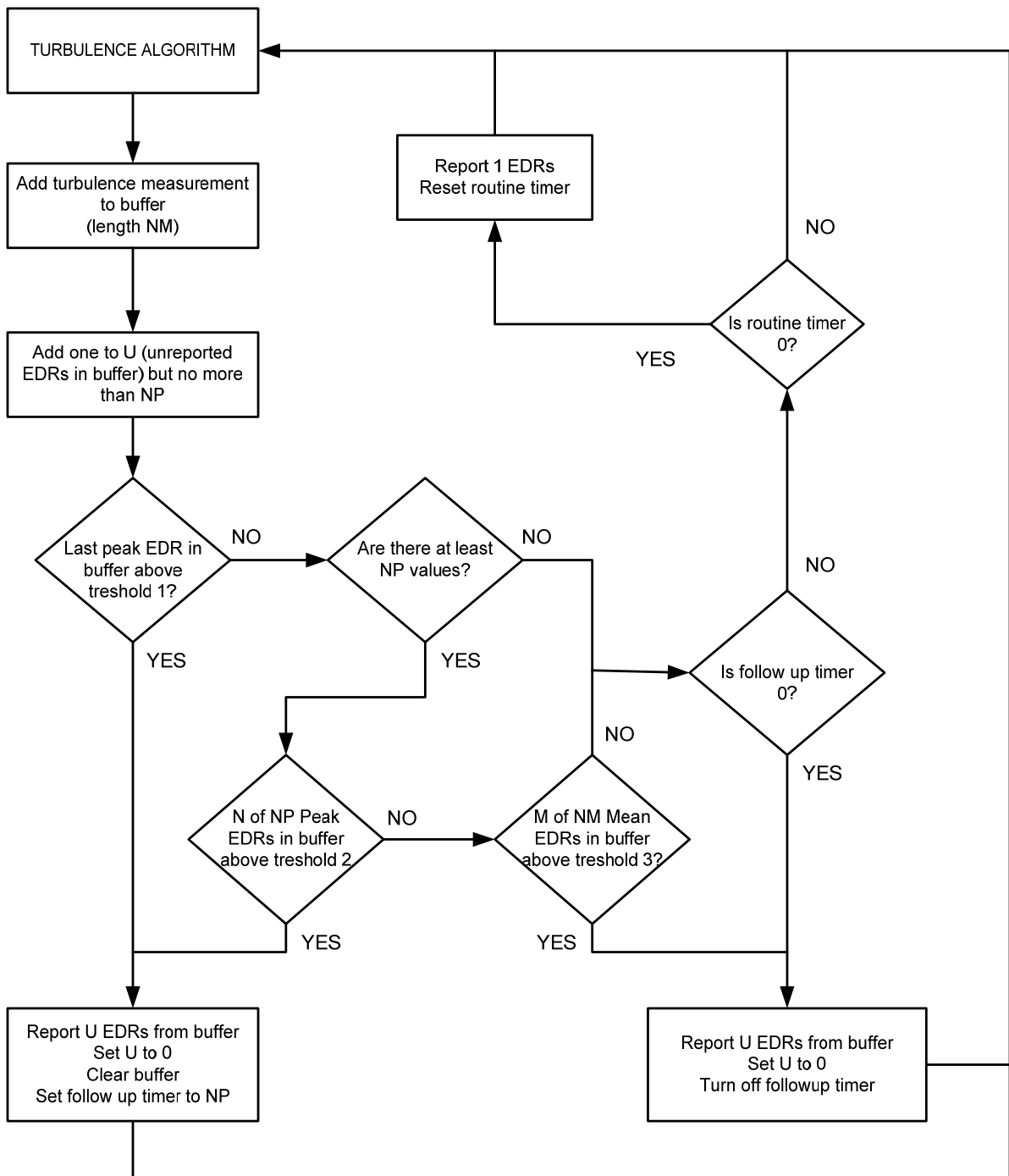


Figure6: EDR Reporting Logic Flowchart

## C.2 Atmospheric Water Vapor Content

Depending on the water vapor sensor installed, the software will be capable of reporting atmospheric water vapor content for downlink in 3 ways:

1. *Mixing ratio (r)*: defined to be the ratio of the mass of water vapor content to the mass of dry air of an air sample. The units of r are g/kg.  
Resolution:  $1 \times 10^{-6}$  kg/kg.  
Range: 0 to 38 g/kg.
2. *Relative humidity (RH)*: defined to be the density of water vapor present in the atmosphere expressed as a percentage of the density of water vapor present when the air sample is saturated (air pressure and temperature held constant). That is:  
 $RH = 100 \times (\text{density of actual water vapor} / \text{density of saturated water vapor})$   
Resolution: 0.01%.  
Range: 0 to 100%  
A WV/Humidity value reported as a relative humidity percentage value is reported in hundredths of percent and with Q = U, i.e. nnnnnU. For example, 05000U indicates that water vapor is reported as humidity with a value of 50.00%.
3. *Dew point temperature (DPT)*: the temperature to which air must be cooled in order for it to become saturated (air pressure held constant. The units of DPT are degrees Celsius (°C).  
Resolution: 0.1C  
Range: -99 to 49C

The software will require a configuration parameter to determine from which sensor the water vapor content should be acquired and, as a consequence, how the water vapor content should be encoded.

Water vapor content will be reported in the downlink message as nnnnnQ. Where nnnnn is the coded water vapor content and Q is a quality control parameter. The value of Q will be dependent on the type of sensor employed and the units in which the water vapor content is reported.

**Table 25 : Water Vapor Configuration Criteria**

WATER VAPOR SENSOR	CONFIGURATION PARAMETER	DOWNLINK FORMAT (NNNNN)	QC FORMAT (Q)
WVSS-II	1	MIXING RATIO	SEE TABLE 26
?	2	HUMIDITY	U
?	3	DEW POINT TEMPERATURE	D

In order to obtain the highest quality water vapor content data on the ground, it is always preferable to downlink the water vapor sensor output variable as provided rather than converting to one of the two alternative derived variables, e.g. if the sensor provides mixing ratio, then that is what should be reported rather than converting to relative humidity or dew point temperature for reporting.



At the time this specification was prepared, the only sensor deemed to be capable of meeting operational and performance requirements for use with AMDAR was the SpectraSensors WVSS-II sensor.

## C.2.1 The WVSSII Sensor

### C.2.1.1 Introduction

The second-generation Water Vapor Sensing System (WVSS-II) for commercial aircraft uses a diode laser for the accurate measurement of water vapor information. The water vapor information available is the mass atmospheric water vapor mixing ratio in kilograms per kilogram (kg/kg).

The WVSS-II has a Systems Electronics Box (SEB) that sends the mixing ratio in ARINC 429 message (Octal Label 303) and bits in Octal Label 270 (related to Q values) to the avionics box (DFDAU or equivalent).

First step is to check the status bits in ARINC 429 message Label 270 (see Section C.2.1.4 below). If, as a result of the status bit checks, the Q value has been set to 2, 3, 4, or 5, then no calculation is made and the data values for mixing ratio are set to (//////) as in Sections C.2.1.3 and C.2.1.4 below.

On the other hand, if the Q value has not been set by the above bit checking, then the Q value is set to 0 and calculations proceed as in Section C.2.1.2 below. The encoding of the mixing ratio value then proceeds as in Section C.2.1.3 below.

### C.2.1.2 Current Input Variables and Calculation

The variables that are input to the processing in the DAS are as follows:

**T<sub>s</sub>**: static temperature expressed in degrees Kelvin; i.e., add 273.15 to degrees centigrade

**P<sub>s</sub>**: static pressure expressed in Pascals; i.e., if pressure in millibars or hPa, then multiply by 100

Note that this may be obtained as STATIC PRESSURE or calculated from PRESSURE ALTITUDE.

**r**: (mixing ratio in kg/kg). Obtained from diode laser of the WVSS-II is supplied in digital form to the DAS at a rate of approximately once every 2.3 seconds.

The mixing ratio is used in the observation but the relative humidity (RH) is used as a control variable. With the above input variables, the calculation of RH is performed in synchronization with the calculation of mixing ratio, using the latest valid samples of pressure and temperature as follows:

Step 1: Calculate water vapor pressure (e) from equation (1)

$$e = (P_s) ( r ) / ( r + 0.62197) \quad (1)$$

Step 2: Calculate saturation vapor pressure (e<sub>s</sub>) from equation (2)

$$e_s = 10^{**} [(10.286 T_s - 2148.909) / (T_s - 35.85)] \quad (2)$$

Step 3: Calculate RH from equation (3)

$$RH = (e/e_s)(100) \quad (3)$$

Step 4: Round the RH value to the nearest integer

Add 0.5 to the floating point RH value, and then truncate the value to an integer.

Step 5: IF RH less than 101%, THEN

- (i) Present the mixing ratio in the 5-character code (NNNNN) according to Section C.2.1.3 below.
- (ii) Set the control character (Q) in the water vapor information field (NNNNNQ) to Q = 0 (see Section C.2.1.4 below).

IF RH equal to or greater than 101%, THEN

- (i) Present the mixing ratio in the 5-character code (Section C.2.1.3 below)
- (ii) Set Q = 1 (Section C.2.1.4 below)

#### *C.2.1.3 Presenting the 5-character Mixing Ratio Field*

The mass mixing ratio is broadcast from the SpectraSensors WVSSII sensor on ARINC 429 label 303. For detailed information see SpectraSensors DWG No. 01021-00027, Rev D or later approved revisions.

The mass mixing ratio is computed within the WVSS-II software as a floating point number in kg/kg. In order to represent this number as an integer variable in the 32-bit ARINC word, this number is multiplied by  $2^{20}$  and sent to the avionics box. So in order to use the value needs to be divided by  $2^{20}$  before the data can be encoded.

The water vapor information is presented as a six-character field (NNNNNQ) where the first five characters are integers (NNNNN) with the following meaning:

$$NNNNN = N_1N_2N_3N_4N_5 = N_1 \cdot N_2 \cdot N_3 \cdot N_4 \times 10^{(-3 - N_5)}$$

Example:  $12345 = 1234 \times 10^{-3-5} = 1234 \times 10^{-8} \text{ kg/kg}$

#### *C.2.1.4 The Quality Control Character (Q)*

The value Q is a quality control character and its ultimate nature has the meaning defined in the Table below.

Table 26 : WVS-II Quality Control Parameter

Q	System State	Software Logic	Data Output
0	Normal operation	Air/Ground = Air	NNNNN0
1	RH greater than or equal to 101%	RH => 101%	NNNNN1
2	Input laser power low	Laser < 5% of initial power	/////2
3	Probe WV temp. input out of range	Proprietary information	/////3
4	Probe WV pressure input out of range	Proprietary information	/////4
5	Spectral line out of range	Proprietary information	/////5
6	Not defined		/////6
7	Not defined		/////7
8	Numeric error	e.g., divide by zero	/////8
9	No WVSS installed	No WVSS installed	/////9

The Q values are based upon the information in various bits in the Octal label 270 (message status) sent by the SEB. **This is the first action, to check these bits!**

If Bit 13 in label 270 is “1” then laser power is low.

Set Q = 2, data is not computed and the 6 character code is /////2

If Bit 14 in label 270 is “1” then the temperature sensor in the measurement cell is out of range.

Set Q = 3, data is not computed and the 6 character code is /////3

If Bit 15 in label 270 is “1” then the pressure sensor in the measurement cell is out of range.

Set Q = 4, data is not computed and the 6 character code is /////4

If Bit 16 in label 270 is “1” then the spectral line is out of range.

Set Q = 5, data is not computed and the 6 character code is /////5

When all of the bits (#13 through #16) are zero – that is no problems - calculation is performed as in Section C.2.1.2 and C.2.1.3. If the calculation is performed without error the data is encoded as in Section C.2.1.3 and Q is set to 0 (zero). If RH is greater than 100%, then the data is encoded as in Section C.2.1.3 and Q is set to 1. If a numerical error occurs in the calculations, the data is set to solidi (///// ) and Q is set to 8 – so the 6 character code is /////8.

## Appendix D Data Compression

In order to minimize the number of character in a message and thereby transmission cost, two coding techniques are applied to the message contents. The first technique codes some numeric values in the remaining observations as delta changes from their previous values – this is a saving because most of the quantities are physical values that vary slowly with time. The second technique codes all integer numeric values in the message into the full set of available printable characters – e.g. a range of 19 to +20 can be mapped onto 40 printable characters, the so-called base 40 compression.

### D.1 Base-40 Compression

A base40 data compression scheme can be applied to the integer values in the message. The integer values are ‘mapped’ to 40 printable characters according to Table 27.

Table 27 : Base 40 Conversion Chart

	0	1	2	3	4	5	6	7	8	9
0X	0	1	2	3	4	5	6	7	8	9
1X	A	B	C	D	E	F	G	H	I	J
2X	K	L	M	N	O	P	Q	R	S	T
3X	U	V	W	X	Y	Z	:	,	-	.

- ◆ Find the range that the value to compress will fall into.  $[ 0 - (40^y)/2 , (40^y)/2 - 1 ]$  will be the form of the range, where y is the smallest integer =>1 to make the value to compress fall into the range (see Table 28).
- ◆ Add the base40 offset provided in Table 30 and Table 31.
- ◆ The base40 offset is added to the integer value to ensure only positive integers.
- ◆ Take the new value and convert to a base 40 character string.

Table 28 : Base40 Dynamic Ranges

CHARACTERS REQUIRED (Y VALUE)	MINIMUM VALUE	MAXIMUM VALUE
1	-20	19
2	-800	799
3	-32,000	31,999
4	-1,280,000	1,279,999
5	-51,200,000	51,199,999
6	-2,048,000,000	2,047,999,999

Important items to note

- ◆ Values outside of the range  $[-2,048,000,000 .. 2,047,999,999]$  cannot be converted and shall return ‘/’;
- ◆ Decompressing a string containing non valid characters will return 2147483647;

## D.2 Message format, Compressed

When applying delta Base40 the format for the message format changes as follows:

Table 29 : Header, compressed

LINE NUMBER	CHARACTER NUMBER	# OF CHAR	CONTENT	FORMAT	NOTES
1	1-3	3	AMDAR MESSAGE VERSION	"A01"	
2	1-26	1 TO 26	OPTIONAL PARAMETER INDICATION	# OR A THRU Z	SEE OPTIONAL PARAMETERS
3	1-7	8	AMDAR AIRCRAFT IDENTIFIER	AANNNN	1
3	8	1	NORMAL (N) OR COMPRESSED (C)	N OR C	2
3	9	1	TIME BASED (0) OR PRESSURE BASED SCHEME (1)	0 OR 1	
3	10-13	4	DEPARTUREAIRPORT	AAAA	3
3	14-17	4	ARRIVALAIRPORT	AAAA	3

**Notes:**

1. The AMDAR identifier is assigned by the requesting NMHS.
2. Normal means the data is not compressed. Compressed means the data is encoded using the compression scheme described in Appendix D.
3. Departure and Arrival airport are represented by their ICAO code. Reporting of these fields is optional but if available, strongly recommended.

Table 30 : Basic Observation Format, compressed

DESCRIPTION	TYPE	BASE40 OFFSET	ABSOLUTE RANGE	DELTA ALLOWED RANGE	CHARACTERS	
					FIRST OBS	SUBSEQ OBS
OBSERVATION TYPE INDICATOR	10X ABSOLUTE	N/A	N/A	N/A	1	1
LATITUDE (IN SECONDS)	1 X ABSOLUTE 9X DELTA	1,280,000 32,000	-324000 TO +324000 SECONDS	-32000 TO +31999 SECONDS	4	3
LONGITUDE (IN SECONDS)	1 X ABSOLUTE 9X DELTA	1,280,000 32,000	-648000 TO +648000 SECONDS	-32000 TO +31999 SECONDS	4	3
DAY/TIME (UTC)	1 X ABSOLUTE 9X DELTA	0 0	0 TO 2678399 SECONDS INTO THE MONTH	0 TO 32000 SECONDS	5	3
PRESSURE ALTITUDE IN TENS OF FEET (REFERENCES AGAINST STANDARD ICAO ATMOSPHERE)	10 X ABSOLUTE	32,000	-100 TO +5,000 TENS OF FEET	N/A	3	3
TEMPERATURE	10 X ABSOLUTE	800	-800 TO +799 TENTHS OF C	N/A	2	2
WIND DIRECTION	10 X ABSOLUTE	0	0 TO 360 DEGREES	N/A	2	2
WIND SPEED	10 X ABSOLUTE	0	0 TO +800 KNOTS	N/A	2	2
ROLL ANGLE FLAG	10 X CHARACTER	0	N/A	N/A	1	1
<b>TOTALS</b>					24	20

Table 31 : Optional parameters, compressed

DESCRIPTION	TYPE	BASE40 OFFSET	ABSOLUTE RANGE	DELTA ALLOWED RANGE	CHARACTERS	
					FIRST OBS	SUBSEQOBS
EDR	10 X CHARACTER	N/A	N/A	N/A	9*	9*
DEVG	10 X ABSOLUTE	0	0 TO 800 TENTHS M/SEC	N/A	2*	2*
TRUE AIRSPEED	10 X ABSOLUTE	0	0 TO 999	N/A	3	3
TRUE HEADING (TENTHS OF DEGREES)	10 X ABSOLUTE	0	0 TO 3599	N/A	3	3
GNSS ALTITUDE	10 X ABSOLUTE	0	-100 TO +5,000 TENS OF FEET	N/A	3	3
ANTI-ICE	10 X ABSOLUTE	0	0 TO 2	N/A	1	1
A/C CONFIGURATION INDICATOR	10 X ABSOLUTE	0	0 TO 15	N/A	1	1
WATER VAPOR	10 X ABSOLUTE	0	0 TO 99999	N/A	4	4
WATER VAPOR QUALITY	10 X CHARACTER	N/A	N/A	N/A	1	1
ICING	10 X ABSOLUTE	0	0 TO 2	N/A	1	1
TOTALS					20+7*	20+7*

\* If the observation is a routine EDR observation, the total number would be 20+9= 29

The next page explains two methods on how to code input values to their base40 character representation. The user may use either method as long as the result is the expected base40 encoding.

**COMPRESSION EXAMPLE 1:** To code latitude 3°43'30" South in seconds

**Step 1 (if required)**

Convert value into the required units, in this case seconds  
 South = ((3 x 3600) + (43 x 60) + 30) x (-1) = -13,410 seconds

**Step 2**

The Absolute Range for Latitude specifies that 4 characters are utilized to provide the required range of values and an offset of 1,280,000 is used (see Table 30).

**Step 3**

Add the required offset to the value to get the coded value:  
 Coded value = -13,410 + (40<sup>4</sup>)/2 = -13,410 + 1,280,000 = 1,266,590

**Step 4**

Convert the coded value in to base 40 using Table 27:  
 Character 1 (most significant): Trunc (1,266,590/(40<sup>3</sup>)) = 19 → check Table 27 → 19 = J

Remainder = 1,266,590 - (19 x 40<sup>3</sup>) = 50590  
 Character 2 Trunc (50,590/(40<sup>2</sup>)) = 31 → check Table 27 → 31 = V

Remainder = 50,590 - (31 x 40<sup>2</sup>) = 990  
 Character 3 Trunc (990/(40<sup>1</sup>)) = 24 → check Table 27 → 24 = O

Remainder = 990 - (24 x 40<sup>1</sup>) = 30  
 Character 4 (least significant) → check Table 27 → 30 = U

CODED CHARACTER STRING = JVOU

## COMPRESSION EXAMPLE 2:

Pressure Altitude is measured at 38,990 feet.

### Step 1 (if required)

Convert value into the required units, in this case tens of feet:  $38,990 / 10 = 3,899$

### Step 2

According to table 24 the base40 offset for pressure altitude is 32,000 and three characters are used. Add the required offset to get the input value: Input value =  $3,899 + (40^3)/2 = 3,899 + 32,000 = 3,5899$

### Step 3

Convert the coded value in to base 40 using Table 27:

if input value  $\geq 40$  then

least significant output character =  $\text{MOD}(\text{input value}, 40) = 19 \rightarrow$  check Table 27  $\rightarrow 19 = J$

input value =  $\text{INT}(\text{input value} / 40) = 897$

if input value  $\geq 40$  then repeat the first step

second output character =  $\text{MOD}(\text{input value}, 40) = 17 \rightarrow$  check Table 27  $\rightarrow 17 = H$

input value =  $\text{INT}(\text{input value} / 40) = 22$

The input value is no longer  $\geq 40$ , the most significant output character is M (corresponding to 22)

CODED CHARACTER STRING = MHJ

Compressed report example

```
A01
#
AZ0001N1EHAMKJFK
0 L-A Q.KX008 UKHKPKPG
100K00K00K0W0HKQKPG
100K00K00K0XKHKQKPG
100K00K00K0Z0HKQKPG
100K00K00K0:KHKQKPG
100K00K00KK00HKQKPG
100K00K00KM7KHKQKPG
300K00K00KM7KHKQKPG
```

### ***A report with an invalid parameter (in this case Wind Direction not valid)***

```
A01
#
AZ0001N1EHAMKJFK
0 L-A Q.KX008 UKHK//KPG
100K00K00K0W0HK//KPG
100K00K00K0XKHK//KPG
100K00K00K0Z0HK//KPG
100K00K00K0:KHK//KPG
100K00K00KK00HK//KPG
100K00K00KM7KHK//KPG
300K00K00KM7KHK//KPG
```



## Appendix E Platform Specific Information

This chapter provides information on systems from various vendors, relevant to the development of AMDAR. The information is based on vendor input and user experience. If you find anything in this chapter missing or incorrect please contact the WMO.

### E.1 Honeywell data systems

Honeywell AMDAR/ARINC620 Compatible Hardware and Software

Product name	HW part number	Core software PN	AOC/application PN
ACARS	965-0728-xxx	Note 1	998-1375-508 or newer Note 2
CMU	965-0758-xxx	Note 1	998-2141-509 or newer Notes 3, 4
ATSU	Any HPS compatible with the AOC is acceptable	Note 5	998-2459-505 or 998-2794-501 or newer Note 4

Notes:

Note 1: Any core software compatible with the AOC is acceptable.

Note 2: Standard Application Operational Software, 998-1375-508. Modified to replace version 1 of the ARINC 620 Meteorological Weather Reporting Function with Version 2. Some bugs were found and fixed in later releases.

Note 3: Standard Application Operational Software 998-2141-509. Modified to replace version 1 of the ARINC 620 Meteorological Weather Reporting Function with Version 2. Some bugs were found and fixed in later releases.

Note 4: Earlier software contains ARINC 620 version 1.

Note 5: Any host platform software (HPS) compatible with the AOC is acceptable. Delta BDS and ACMS database may be required to provide data.

If upgrading existing software, then the latest version is recommended.

In many cases the DFDAU needs to be programmed to provide 429 data to ACARS/CMU/ATSU.

## E.2 Teledyne Controls data systems

Teledyne Hardware suitable for hosting AMDAR / ARINC 620 weather report application software

Hardware	Part No.	Remarks
DFDAU as a DMU	2227000-335, -805	Older DMU types have limited CPU capacity. For these types it is recommended to implement the most basic functionality only.
DFDAU	2233000 – 8xx	-825 for KLM only
DMU	2232000 2234000 2239000	Older DMU types have limited CPU capacity. For these types it is recommended to implement the most basic functionality only.
DFDAU	2235000 – 83, -85	
FDIMU	2234320-01-01	Uplink capability for this type is limited, not all configuration options can be supported.
Any Teledyne A320 DMU	795020 /030, /040	
ACARS MU WITH STARS	2231500 – 51, 52	
CMU	2231900 – 1 / -2	

Acronyms:

ACARS Aircraft Communications and Reporting System

ACMS Aircraft Conditioning and Management System

CMU Communications Management Unit

DFDAU Digital Flight Data Acquisition Unit

DMU Data Management Unit

MU Management Unit

## Appendix F Avionics Information Form

This form is intended to gather information on avionics systems available that may allow AMDAR to be implemented onboard an aircraft. The form can be used when it is not immediately clear to the airline or met engineer if the available systems are capable of hosting AMDAR. The information can be send to the WMO who will then try to find out if the systems mentioned in the form are capable and in what way.

The information the WMO is after are types and manufacturers of the onboard data acquisition systems, communication systems and other systems that may be relevant.

The form allows for one aircraft type. If more aircraft types need to be specified, please copy and paste the table for as much types as required. The table headers are described below.

*Operator:* Aircraft Operator

*Aircraft Type:* Type of aircraft the system is installed on (e.g. B747-400, A340-300, C56Xetc)

*# of A/C:* The number of aircraft involved

*LRU name:* Name of the LRU (Line Replaceable Unit) (e.g. DFDAU, ATSU,CMU etc.)

*Manufacturer:* Name of LRU Manufacturer (e.g. Honeywell, Sagem, Teledyne etc.)

*LRU P/N:* Acquisition system LRU Part Number

*Software P/N:* If known, acquisition system software Part Number

*S/W Control:* Who controls/programs the acquisition system software  
(Manufacturer/Operator/Other)

OPERATOR:				
AIRCRAFT TYPE:		# OF A/C:		
LRU NAME	MANUFACTURER	LRU P/N	SOFTWARE P/N	S/W CONTROL

## Appendix G      AOSFRS Version Control

<u>VERSION</u>	<u>DATE OF VERSION</u>	<u>DESCRIPTION</u>
Version 1.0	July 16 2013	Specifies version 1.0 of the AMDAR Onboard Software Functional Requirements Specification. The preliminary draft version of this specification was developed under the consultancy of Mr Frank Tamis, Aircraft Data Engineering & Consultancy and reviewed and finalized for publication by the WMO Commission for Instruments and Methods of Observations (CIMO) Task Team on Aircraft-based Observations.