World Meteorological Organization

AMDAR Onboard Software Functional Requirements Specification

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Revision Data

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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 Integrated Global Observing System, which is defined and maintained under the WMO World Weather Watch Program[1].

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 Services, 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 OnboardSoftware 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.

[1] The WMO World Weather Watch Programme: 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. Theterms “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. Theterms “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 animplementation 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
ARINC Aeronautical Radio, Incorporated
ASDAR Aircraft to Satellite Data Relay
DAS Data Acquisition System
DEVG Derived Equivalent Vertical Gust
EDR Eddy Dissipation Rate
GNSS Global Navigation Satellite System
IATA International Air Transport Association
ICAO International Civil Aviation Organization
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 fullAMDAR 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 relayed to the National Meteorological Services (NMS) and other authorized users as shown in Figure 1. Data are received at the data processing centersof the NMS where they are decoded and undergo basic quality control checks before being reformatted for distribution to Data Users both internal to the NMS and externally to other NMSs via the WMO Global Telecommunication System (GTS).

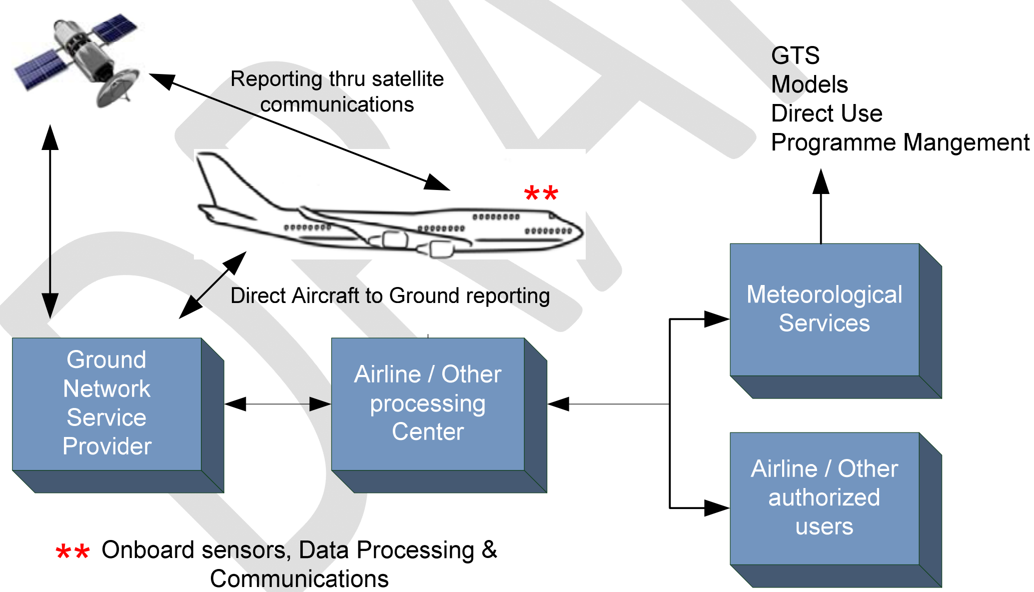


Figure 1: AMDAR Data Flow

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

2.2 AMDAR Onboard Process

The purpose of the airborne part of the AMDAR Process, henceforth referred to as the AOP, is to collect, process and transmit meteorological data from sensors onboard the aircraft. The primary functions of the AOP are:

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

To meet these primary functional requirements, AMDAR relies on the availability of onboard data acquisition systems that are capable of being programmed to perform the required functions. Therefore, the first and most fundamental requirement of the AMDAR Onboard System is that the aircraft must have a Data Acquisition System (DAS) that must be programmable and support interfacing to all the required data inputs and to the aircraft's communications system.

An example of such an onboard system is illustrated in Figure2 , which shows schematically the principal data sources feeding into a DAS. Note that the configurations and availability of systems varies widely between aircraft models and airline fleets.

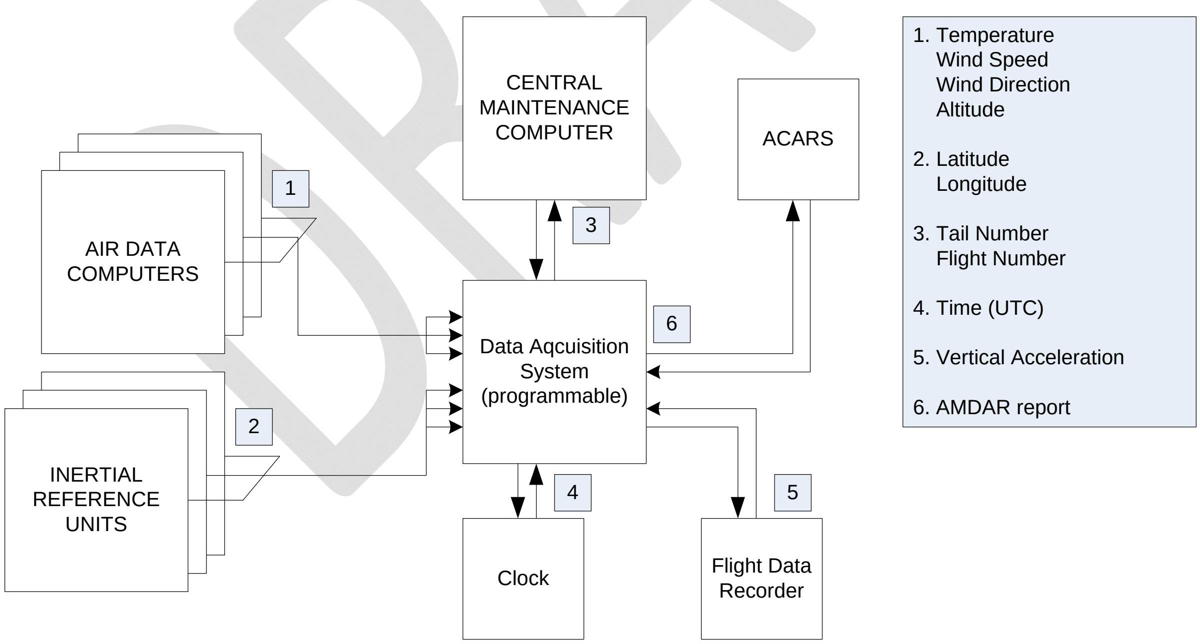


Figure2: Example Data Acquisition System

Typical inputs to the DAS are, for example, Pressure Altitude or Static Air Pressure, Wind Speed/ Direction and others. These input parameters are processed by the software according to predefined sampling frequencies and the resulting data variables are stored as a meteorological "observation". 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.

The actual triggering of the programmatic processes that create these 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.

Additionally, 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 these 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 NMS and airlines to manage data volumes and eliminate redundant observations and messages through real-time AMDAR software modification either prior to or during aircraft flight and on a flight-by-flight basis.

The end result of the AMDAR onboard system 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 NMS. The contents of the messages are processed and the data are ingested into meteorological databases and applications.

2.3 Other Specifications

There are many possible format specifications for meteorological messages from aircraft. In order to avoid the proliferation of data formats and reduce the overheads and complexity for compliance by ground processing systems, this document provides a functional requirements specification that will be known as AMDAR Onboard Software Functional Requirements Specification (AOSFRS) Version 1.0. This specification is based on the ASDAR Specification[2], the E-AMDAR AAA Version 2.0 Specification (AAA V2)[3]andthe AMDAR AAA Version 3.0 specification (AAA V3)[4]. All information in this document supersedes the previously mentioned documents.Some information in this document is derived from

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

[3] EUMETNET AMDAR AAA AMDAR Software Developments – Technical Specification, Version 2, 1 August 2000.

[4] PROGRAM OPERATIONS AND STANDARDS OBSERVATIONS SPECIFICATION 2006-1, AMDAR AAA Version 3.0 Software Requirements Specification, 23 November 2006

ARINC specification 620 (meteorological report version 1 thru 5). The ARINC 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.

To allow the user to choose between optional formats, this specification shall refer to the ARINC 620 (latest version) specification where appropriate.

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

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

As described in chapter 2, the primary functions of the AMDAR Onboard Process are:

- 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 process. This chapter aims to translate the functions in this schematic into functional requirements for the AMDAR onboard software.

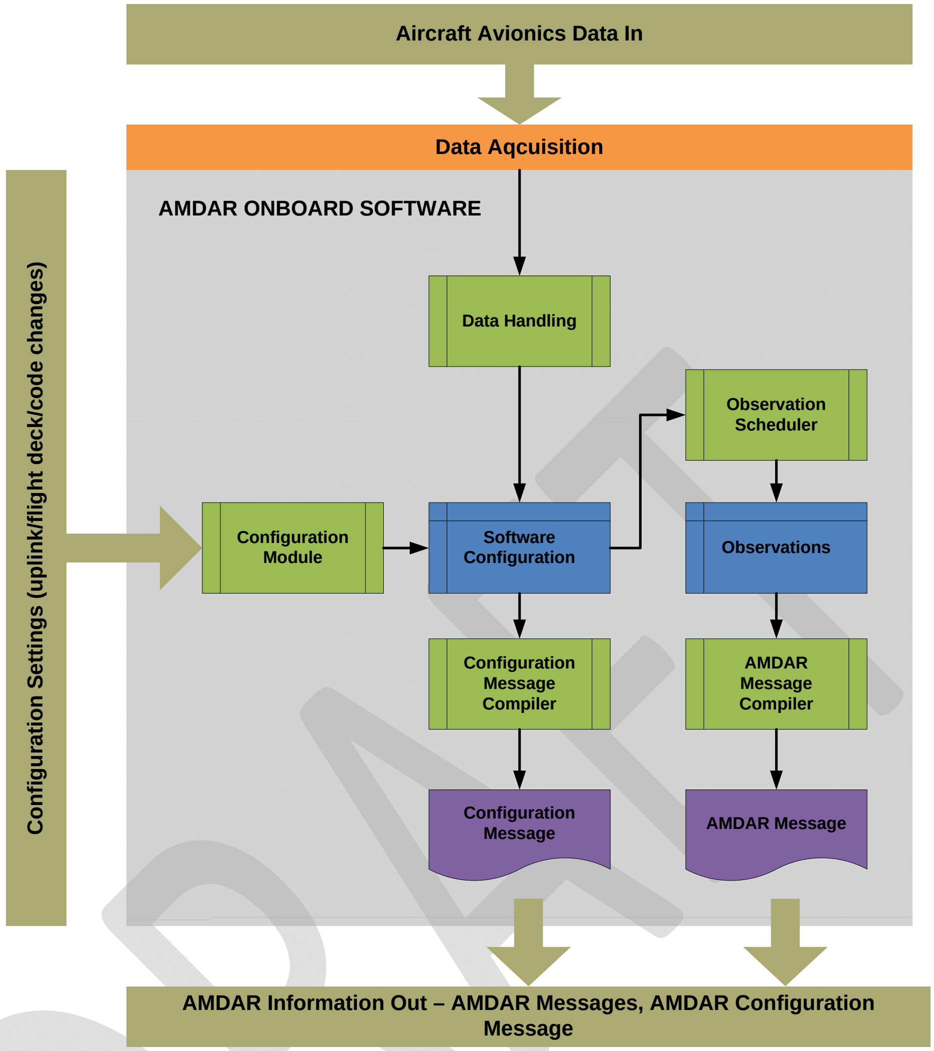


Figure3: AMDAR Onboard Process

3.1 Data Acquisition

The data acquisition system 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 (e.g. the latitude comes from the inertial reference system but this source is not connecteddirectly to the AOS. Latitude is however transmitted to the 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 IRS)

The tables below provide the input signals that need 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).

Table 1: Input Signals - Required

DESCRIPTION	UNIT	RANGE	ACQ RATE	
			PREFERRED	MAX

AIRCRAFT ID	INT	N/A	N/A	N/A
AIR/GROUND SWITCH *OR* WEIGHT ON WHEELS	DISCRETE	N/A	1Hz	1HZ
COMPUTED AIR SPEED	KTS	0 TO 800 KNOTS	1Hz	2HZ
DATE - DAY	DD	0 - 31	1Hz	4HZ
GMT - HOURS	HH	00 - 23	1Hz	2HZ
GMT - MINUTES	MM	00 - 59	1Hz	2HZ
GMT - SECONDS	SS	00 - 59	1Hz	2HZ
LATITUDE	DEGR	90°S TO 90°N	1Hz	4HZ
LONGITUDE	DEGR	180°E TO 180°W	1Hz	4HZ
PRESSURE ALTITUDE IN ICAO STANDARD ATMOSPHERE 1) BAROMETRIC ALTITDUE IN QNH ADJUSTED ATMOSPHERE1)	FT	-1,000 TO 50,000 FEET	1Hz	2HZ
STATIC AIR TEMPERATURE	DEGR. C	-99°C TO +99°C	1Hz	2HZ
STATIC PRESSURE 2)	HPA (=MB)		1Hz	1HZ
WIND DIRECTION TRUE	DEGR	0° TO 360°	1Hz	2HZ
WIND SPEED	KTS	0 TO 800 KNOTS	1Hz	2HZ

Note 1: Pressure Altitude in ICAO Standard Atmosphere = PALT

Barometric Altitude in QNH adjusted atmosphere = BALT

If both PALT and BALT are available, PALT should be used.

Note 2: 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:

$$SP\ (hPa) = 1013.25[1 - 10^{-6} x6.8756(PALT)]^{5.2559}$$

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

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

Table 2: Input Signals - Recommended

DESCRIPTION	UNIT	RANGE	ACQ RATE	
			PREFERRED	MAX
DEPARTURE STATION	CHAR	N/A	N/A	N/A
DESTINATION STATION	CHAR	N/A	N/A	N/A
VERTICAL SPEED[3)]	FT/MIN	-2000 TO 2000	1Hz	1HZ
GROSS WEIGHT	KG	N/A	1Hz	16HZ
VERTICAL ACCELERATION	G	-3G TO +6G	8Hz	4HZ
ROLL ANGLE	DEGR	-180° TO 180°	1Hz	1HZ
PITCH ANGLE	DEGR	-90° TO 90°	1Hz	1HZ

Note 3: 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	RANGE	ACQ RATE	
			PREFERRED	MAX
WATER VAPOR DATA / RELATIVE HUMIDITY	NOTE 4		1Hz	4HZ
ICING DATA	DISCRETE	N/A	1Hz	4HZ
FLAPS	DEGR		1Hz	4HZ
GEAR DOWN/UP	DISCRETE	N/A	1Hz	2HZ
GNSS ALTITUDE	FT	-1,000 TO 50,000 FEET	1Hz	1HZ
GROUNDSPEED	KTS	0 TO 800 KNOTS	1Hz	2HZ
TRUE TRACK	DEGR		1Hz	2HZ
TRUE HEADING	DEGR	0° TO 360°	1Hz	2HZ
TRUE AIRSPEED	KTS	0 TO 800 KNOTS	1Hz	2HZ

Note 4: Water Vapor/Humidity is measured and reported either as mixing ratio or relative humidity, depending on the type of sensor employed. The mass mixing ratio value is to be reported as nnnnn = n1n2n3n4n5 which implies a mass mixing ratio value of (n1n2n3n4) x $10^{(-3-n5)}$ kg/kg; e.g., if nnnnn = 12345, then the mass mixing ration is given by 1234 x $10^{(-3-5)}$ = 1234 x 10^{-8} kg/kg.
Relative Humidity is reported as nnnnn where the range of nnnnn is between 00000 and 10000 in hundreds of per cent.

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 2and 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 either not reported, or be masked as specified, usually with a solidi ('/').

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.

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 processes data but no observation nor are transmissions made

3.2.4.1.2 Ascent

The aircraft is in ascent when:

1. Computed Airspeed > 100 kts and
2. Altitude Rate > +200 feet/min and
3. a. Pressure based scheme: Pressure Altitude <= Top of Climb (see Table 7)*or*
   b. Time based scheme: Flight time since take-off <= Ascent Total Duration (see Table 7)

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 flight when:

1. Computed Airspeed > 100 kts*and*
2. a. Pressure based scheme: Pressure Altitude > Top of Climb (see Table 7)*or*
   b. Time based scheme: Flight time since take-off > Ascent total duration (see Table 7)

3.2.4.1.4 Descent

The aircraft is in descent when:

1. Computed Airspeed > 100 kts*and*
2. Altitude Rate < -200 feet/min *and*
3. Pressure Altitude < Top of Descent (see Table 9)

3.2.4.2 Turbulence Indicator

A turbulence indicator should be added to the meteorological observation data. Indicators that should be used are:

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

For details on DEVG calculation see appendix C.1.1

For details on EDR calculation see appendix C.1.2

3.2.4.3 Water Vapor / Relative Humidity / Dew Point

Water Vapor/ Relative humidity or Dew Point datamay be added to the meteorological observation data. 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 added to the meteorological observation data.

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) (Mode 1), 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, H, W or U, with the corresponding meaning provided in the table below.

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

The values W and U are used within an En-route Weather message only to indicate that the Wind Speed constitutes a Maximum Wind Report as per the criteria defined in Paragraph 3.4.1.1.

Table 4: Roll Angle Flag values

ROLL ANGLE FLAG VALUE	MEANING	MODE
B	$\lvert RA \rvert \geq 5°$ or ($\lvert RA \rvert \geq 3°$ and $\lvert PA \rvert \geq 3°$)	1
G	$\lvert RA \rvert < 5°$ or ($\lvert RA \rvert < 3°$ and $\lvert PA \rvert < 3°$)	1
H	Roll angle unavailable or undefined	1 and 2
W	Maximum wind event and RA and PA correspond to value G.	1 and 2
U	Maximum wind event and RA and PA correspond to value B.	1 and 2
0	$0° \leq \lvert RA \rvert < 1°$	2
1	$1° \leq \lvert RA \rvert < 2°$	2
2	$2° \leq \lvert RA \rvert < 3°$	2
3	$3° \leq \lvert RA \rvert < 4°$	2
4	$4° \leq \lvert RA \rvert < 5°$	2
5	$5° \leq \lvert RA \rvert < 7°$	2
6	$7° \leq \lvert RA \rvert < 10°$	2
7	$10° \leq \lvert RA \rvert < 14°$	2
8	$14° \leq \lvert RA \rvert < 20°$	2
9	$20° \leq \lvert RA \rvert$	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 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.

3.4 Observation Frequency

The frequencies at which meteorological observations are made depend on the phase of flight the aircraft is in. Each observation has the same ordering of meteorological information but the triggering frequency can vary with phase.

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

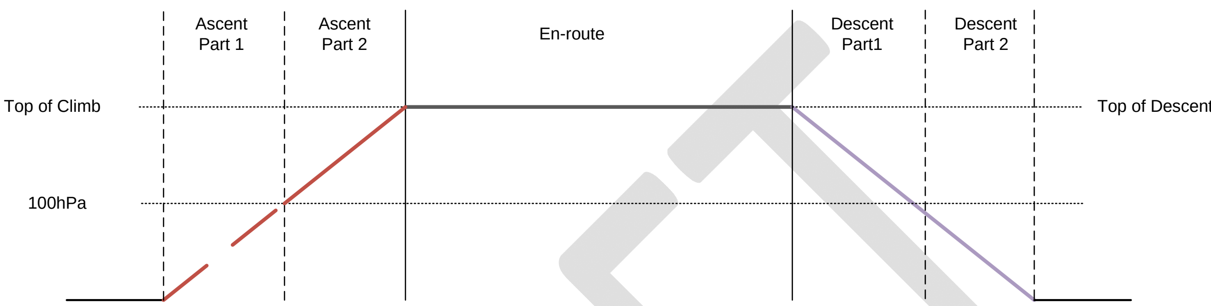


Figure4: AMDAR flight phases

The table below describes the observing frequency for the various flight phases. Paragraphs following provide detailed information on the observing frequency

Table 6: AMDAR observing Interval by flight phase

	Pressure Based Scheme	Time Based Scheme
Ascent Part 1	5 or 10 hPa intervals for first 100 hPa	3 to 20secs intervals (default 6) for 30 to 200secs (default 90)
Ascent Part 2	25 or 50 hPa intervals above first 100 hPa	20 to 60secs intervals (default 20) for 490 to 1050secs (default 510)
En-route:	1 to 60 minute intervals (default 7)	
Descent Part 1	25 or 50 hPa intervals from TOD to last 100 hPa	20 to 300secs intervals (default 40) from top of descent to touchdown.
Descent Part 2	5 or 10 hPa intervals for last 100 hPa	

The paragraphs below provide detailed information on the content of Table 6.

3.4.1 En-route Observations

The En-route observation frequency is generic to both the pressure – and time based scheme. Observations shall be triggered at set time intervals only. En-route data measurements should begin at the conclusion of Ascent and terminate when Descent observation measurements begin.

For time interval values see Table 8.

3.4.1.1 Maximum Wind Observation

This facility is required to aid in locating jet stream cores and is applied in en-route flight phase only. The highest wind speed measured between a sequential pair of routine observations is labeled maximum wind. 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, using the maximum wind indicator (see Table 4)

3.4.2 Pressure Based Scheme

3.4.2.1 Routine Observations

Routine observation will ensure data is still collected at regular time intervals in the case where the aircraft levels off during ascent and/or descent and static pressure triggering can not 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.

Routine observations shall be made at set time intervals during flight phase ascent and 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 paragraph 3.4.1)

3.4.2.2 Ascent

During Phase of Flight 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.

3.4.2.2.1 Initial Observation

Meteorological data measured at the time of the OFF event (take-off).

3.4.2.2.2 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.

3.4.2.2.3 Ascent Part 1

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.

3.4.2.2.4 Ascent Part 2

The eleventh Ascent Target Pressure shall be the nearest multiple of 50 hPa (modifiable to 25hPa) below the tenth Ascent Target Pressure. The twelfth and subsequent Ascent Target Pressures shall follow at 50 hPa (modifiable to 25hPa) intervals decrementing from the eleventh 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.

3.4.2.3 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 touchdown. 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 <u>not</u> include repeats of observations at 50 hPa intervals.

3.4.3 Time Based Scheme

3.4.3.1 Ascent

3.4.3.1.1 Initial Observation

An initial observation is triggered at the “OFF” event.

3.4.3.1.2 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 7

3.4.3.1.3 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 7

3.4.3.2 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 9.

3.5 Message Compilation

3.5.1 Content

Observations are collected and stored during flight. When a pre-set number of observations are stored, a message shall be formed containing these observations.After a message is transmitted, the observations shall be discarded.The message shall have 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)
- Observation data

3.5.2 Format

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

3.5.3 Transmission

Regardless of the format, messages shall be send to the ground as soon as they are complete via the best means possible.

Pending messages shall be send even though the pre-set number of observations has not been reached 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 send with only seven observations. More information on software configuration control can be found in paragraph 3.6.

3.6 Software Configuration Control

It shall be possible to configure the software to allow reporting behavior to be altered.

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

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

Changes to the configuration by one of the methods described above are considered permanent until changed again. If for whatever reason the configuration settings are lost, the settings shall revert to default.

3.6.1 Observation Frequency Control

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

Table 7: 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 Value = 5 or 10 Default = 10
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 Value = 25 or 50 Default = 50
3	nnn	Top of Climb (x100ft)	Default = 200

			Range = 150-350 1)
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 8: 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 9: 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

3.6.2 Reporting Control

3.6.2.1 Reporting on/off

It shall be possible to turn reporting on or off completely or by flight phase, in accordance with the table below:

Table10: AMDAR switch

Characters	Data	Description	Remarks
1	N	Report Activation flag	0 = Reporting off (default) 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

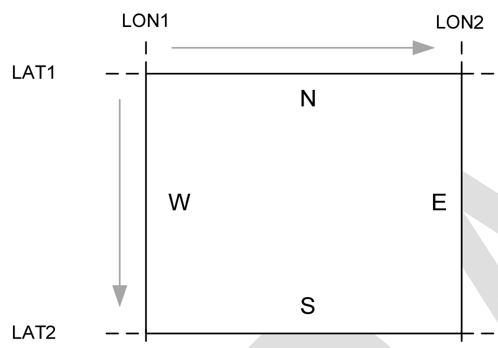
3.6.2.2 Geographical Control boxes

It shall be possible to configure 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 paragraph0).

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 11: 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

It shall be possible to configure a minimum of 20 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 repeated 19 times.

Table 12: Airport control parameters

Characters	Data	Description	Remarks
4	$I_AI_AI_AI_A$	ICAO Airport designator	"0000" = Default
1	F_A	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 shall be possible to configure a single time window during which reporting is inhibited.

Table 13: 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).

3.6.3 Configuration Message

The software shall 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 (in order of preference)

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

For contents and format of the configuration messageseeAppendix B

3.6.4 AMDAR Optimization Message

An AMDAR optimization message may be sent to the NMS and/or airline prior to departure of every flight. This message allows the NMS 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 then one AMDAR equipped aircraft takes off, the system is filled with data that is not required. In order to prevent multiple aircraft sending AMDAR messages, a ground based system determines what 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 Indicator
- Time Out (leaving gate or parking position)
- Departure / Arrival Station

Appendix A AOSFRS message format version 04

A.1 Introduction

This appendix specifies the AOSFRS message format. 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 available.

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, and others may be able to provide a lot more information.

The data that is send to the ground is set up in two sections, the first a header section with information such as the AOSFRS message version and the aircraft identifier, the second part consists of 10 observations with the relevant parameter values. A detailed description is given below.

A.2 Header

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

Table 14 : AOSFRS message header

LINE NUMBER	CHARACTER NUMBER	# OF CHAR	CONTENT	FORMAT	NOTES
1	1-3	3	AMDAR MESSAGE VERSION	"A04"	
2	1-26	1 TO 26	OPTIONAL PARAMETER INDICATION	# OR A THRU Z	SEE OPTIONAL PARAMETERS
3	1-7	8	AMDAR AIRCRAFT IDENTIFIER	AAAAAAAA	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	1	ALTITUDE REFERENCE: PRESSURE ALTITUDE (P) OR BAROMETRIC ALTITUDE (B)	P OR B	3
3	*11-14*	*4*	*DEPARTURE AIRPORT*	*AAAA*	*4*
3	*15-18*	*4*	*ARRIVAL AIRPORT*	*AAAA*	*4*

Notes:

1. The AMDAR identifier is assigned by the requesting met office.
2. Normal means the data is not compressed. Compressed means the data is encoded using the compression scheme described in Appendix D.
3. Pressure Altitude in ICAO Standard Atmosphere = PALT;
   Barometric Altitude in QNH adjusted atmosphere = BALT;
   If BALT is reported, conversion to the Pressure Altitude (PALT) scale will be necessary in ground processing using runway or area QNH at the time of the observation. This is essential before data can be used or exchanged. If both PALT and BALT are available, PALT is preferred.

4. Departure and Arrival airport are represented by their ICAO code. Reporting of these fields is optional but if available, strongly recommended.

A.3 Body

The header shall be followed by 10 meteorological observations, each observation on one line. The observations shall contain the Basic Observation Sequence as described inTable 15. All parameters shall be right-justified.

A.3.1 Basic Observation sequence

Table 15: AOSFRSBasic Observation Sequence 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

Notes:

1. Phase of Flight is indicated as follows:
   Ascent = A
   En-route= R
   Descent = D

2. The day/time is presented as seconds into the month, and is calculated as follows:
   `((DATEDD-1)*86400) + (GMTHH*3600) + (GMTMM*60) + GMTSS`

   Example 1:
   An observation is made on July 1st 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 amended 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 basic observation sequence is followed by one or more optional parameter.For each optional parameter that is added to the basic 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 16 below. All parameters shall be right-justified.

Table 16: AOSFRSOptional Parameters Format

HEADER INDICATOR	# OF CHAR	CONTENT	FORMAT	NOTES	EXAMPLE
A	1	ROLL ANGLE FLAG	N	SEE PARAGRAPH 3.2.4.4	U
B	1 *OR* 9	EDR	C *OR*CNNNNNNNN		E12345678
C	3	DEVG	NNN		7
D	3	TRUE AIRSPEED	NNN		854
E	3	TRUE HEADING	NNN		145
F		GNSS ALTITUDE	NNNN		3750
G	1	ANTI-ICE (ENGINE OR WING OR BOTH?)	N	1	1
H	2	A/C CONFIGURATION INDICATOR	NN	SEE PARAGRAPH 0	01
I	6	WATER VAPOR	NNNNNQ	SEE APPENDIX C.2 OR CIMO?	123450
J	6	RELATIVE HUMIDITY	NNNNNQ	SEE APPENDIX C.2 OR CIMO?	05000U
K	1	ICING	N	2	1

Notes

1. 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:

2. 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:

```
A4
#
AZ0001N1PEHAMKJFK
R-2976  6081 8796613899-525160 25
R-2976  6081 8796613899-525160 25
R-2976  6081 8796613899-525160 25
R-2976  6081 8796613899-525160 25
R-2976  6081 8796613899-525160 25
R-2976  6081 8796613899-525160 25
R-2976  6081 8796613899-525160 25
D-2976  6081 8796613899-525160 25
D-2976  6081 8796613899-525160 25
D-2976  6081 8796613899-525160 25
```

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, using Barometric altitude.

<u>Example 2:</u>

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

```
A04
FG
AZ0001N1BEHAMKJFK
A-2976  6081 8796613899-525160 25U38540
A-2976  6081 8796613899-525160 2538540
A-2976  6081 8796613899-525160 2538540
A-2976  6081 8796613899-525160 2538540
A-2976  6081 8796613899-525160 2538540
A-2976  6081 8796613899-525160 2538540
A-2976  6081 8796613899-525160 2538540
A-2976  6081 8796613899-525160 2538540
A-2976  6081 8796613899-525160 2538540
R-2976  6081 8796613899-525160 2538540
```

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, using Barometric altitude.

<u>Example 3:</u>

Water Vapor, True Airspeed, Anti-ice, A/C config and EDR are available and added to the basic observation sequence, in that order. The message would look like:

```
A04
IDGHB
NL0032N0BWMKKYMML
A-2976  6081 8796613899-525160 25123450854101E12345678
A-2976  6081 8796613899-525160 25123450854101E12345678
R-2976  6081 8796613899-525160 25123450854101E12345678
R-2976  6081 8796613899-525160 25123450854101E12345678
R-2976  6081 8796613899-525160 25123450854101E12345678
R-2976  6081 8796613899-525160 25123450854101E12345678
R-2976  6081 8796613899-525160 25123450854101E12345678
R-2976  6081 8796613899-525160 25123450854101E12345678
D-2976  6081 8796613899-525160 25123450854101E12345678
D-2976  6081 8796613899-525160 25123450854101E12345678
```

This indicates that the observations in the message are basic observations amended with Water Vapor, True Airspeed, Anti-ice, A/C configuration and EDR information, 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, using Barometric altitude

Appendix B AOSFRS ConfigurationMessage

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 messageis only required when it can actually be retrieved from the aircraft somehow.A detailed description is given below.

SA4

I_A……I_A DDDDAAAA S_p $A_S I_{ph} A_a$**G**:I_{sg}**A**:I_{sa}**T**:I_{st}

AInt_{A1}/N/Int_{A2} **R**Int_R **D**Int_{D1}/ Int_{D2}

TOCT_{L1} **TOD**T_{L2} $H_1H_2H_3H_4$

BB$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B **BB**$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B

BB$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B **BB**$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B

BB$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B **BB**$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B

BB$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B **BB**$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B

BB$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B **BB**$_N$ Lat_{Y1}/Lat_{Y2} $Long_{X1}$/$Long_{X2}$ S_B

A1$ICAO_N$/S_A **A5**$ICAO_N$/S_A **A9** $ICAO_N$/S_A **A13**$ICAO_N$/S_A **A17**$ICAO_N$/S_A

A2$ICAO_N$/S_A **A6**$ICAO_N$/S_A **A10**$ICAO_N$/S_A **A14**$ICAO_N$/S_A **A18**$ICAO_N$/S_A

A3 $ICAO_N$/S_A **A7** $ICAO_N$/S_A **A11**$ICAO_N$/S_A **A15**$ICAO_N$/S_A **A19**$ICAO_N$/S_A

A4 $ICAO_N$/S_A **A8** $ICAO_N$/S_A **A12**$ICAO_N$/S_A **A16**$ICAO_N$/S_A **A20**$ICAO_N$/S_A

The Bold and "/"characters are fixed characters.

Table 17: AOSFRSconfigurationmessage contents

PARAMETER	DESCRIPTION	FORMAT	NOTES	EXAMPLE
SA04	STATUS FOR AOSFRS MESSAGE VERSION	AAAA		SA04
I_A……I_A	AMDAR IDENTIFIER (MAX 8 CHARACTERS)	AAAAAAAA		AU0013
DDDD	DEPARTURE AIRPORT	AAAA	ICAO CODE	EHAM
AAAA	ARRIVAL AIRPORT	AAAA	ICAO CODE	KJFK
S_P	PRESSURE BASED (P) OR TIME BASED (T) SCHEME	A		P
A_S	AMDAR SWITCH SETTING	N		7
I_{PH}	FLIGHT PHASE AT TIME OF REQUEST	A	1	A
A_A	AMDAR ACTIVE AT TIME OF REQUEST (Y/N)	A	2	Y
I_{SG}	GEOGRAPHICAL IN RANGE AT TIME OF REQUEST Y/N	A		N
I_{SA}	AIRPORT ACTIVE AT TIME OF REQUEST Y/N	A		Y
I_{ST}	TIME WINDOW ACTIVE AT TIME OF REQUEST	A		Y
INT_{A1}	OBSERVING INTERVAL DURING ASCENT PART 1, IN HPA OR SECONDS	NN		10
N	NUMBER OF OBSERVATIONS MADE DURING ASCENT PART 1	NN		10
INT_{A2}	OBSERVING INTERVAL DURING ASCENT PART 2, IN HPA OR SECONDS	NN		50
INT_R	OBSERVING INTERVAL DURING LEVEL FLIGHT IN SECONDS	NNN		420
INT_{D1}	OBSERVING INTERVAL DURING DESCENT PART 1, IN HPA OR SECONDS	NN		50
INT_{D2}	OBSERVING INTERVAL DURING DESCENT PART 2, IN HPA	NN		10
T_{L1}	TOP OF CLIMB SETTING IN THOUSANDS OF FEET	NNNN		2000

T_{L2}	Top of Descent setting in thousands of feet	NNNN		2000
$H_1H_2H_3H_4$	Time window setting	NNNN		0000
B_N	Geographical box number (0to 9)	N		1
LAT_{Y1}	Latitude value Y1 applied to box B_N in degrees	SNN		30
LAT_{Y2}	Latitude value Y2 applied to box B_N in degrees	SNN		-50
$LONG_{X1}$	Longitude value X1 applied to box B_N in degrees	SNNN		-40
$LONG_{X2}$	Longitude value X2 applied to box B_N in degrees	SNNN		120
S_B	Status of box B_N (1 = Reporting active, 0= Reporting disabled)	N		1
$ICAO_N$	ICAO code of airport number A_N	AAAA		EHAM
S_A	Status of airport (1 = Reporting active, 0 = Reporting disabled)	N		1

Notes :

1. Flight phase characters
   G = Ground
   A = Ascent
   R = En-route
   D = Descent

2. AMDAR active shows if AMDAR is reporting, as follows
   Y = AMDAR is reporting
   N = AMDAR is inactive

<u>MessageExample</u>

```
SA04
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
```

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

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:

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

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:

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

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

= Value of *A* when mass of aircraft equals reference mass

H = altitude in thousands of feet

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

The parameters $c_1, c_2, \ldots, c_5$ depend on the aircraft's typical flight profile. For various aircraft, the appropriate constants, based on the flight profiles indicated, are shown in Table18.

Table18 : DEVG aircraft constants

Aircraft	V_1 knot	V_c knot	M_c Mach	h_1 ft	h_c ft	$\overline{m}$ Tonne	c_1	c_2	c_3 kft	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)

Details of the EDR algorithm and the encoding process will be provided in a future supplement to this standard.

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: 1×10^{-3} g/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 x (density of actual water vapor / density of saturated water vapor)
   Resolution: 0.1%.
   Range: 0 to 100%

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 nnnn 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 19 : Water Vapour Configuration Criteria

Water Vapor Sensor	Configuration Parameter	Downlink Format (nnnnn)	QC Format (Q)
None	0	/////	9
WVSSII	1	Mixing ratio	See Table 20
?	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 only details on the WVSSII sensor were known.

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 DFDAU are as follows:

$\mathbf{T_s}$: static temperature expressed in degrees Kelvin; i.e., add 273.15 to degrees centigrade

$\mathbf{P_s}$: 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 DFDAU at a rate of once every two 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 RHis performed once every two seconds (using the latest pressure and temperature) as follows:

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

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

Step 2: Calculate saturation vapor pressure (e_s) from equation (2)

$$e_s = 10 ** [(10.286\,T_s – 2148.909) / (T_s – 35.85)] \qquad (2)$$

Step 3: Calculate RH from equation (3)

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

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 spectra Sensors WVSSII sensor on ARINC 429 label 303. For detailed information see Spectra Sensors DWG No. 01021-00027, REV.C

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 send 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:

$NNNNN = N_1N_2N_3\ N_4N_5 = N_1 \bullet N_2 \bullet N_3 \bullet N_4 \times 10^{(-3 - N5)}$

Example: $12345 = 1234 \times 10^{-3-5} = 1234 \times 10^{-8}$ 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 20 : WVSII 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 > than or = to 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 4 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 4 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 4 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 4 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 3 and the 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 the Q is set to 1. If a numerical error occurs in the calculations, the data is set to solidi

(/////) and the 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 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 21.

Table 21 : 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 22).

Add the base40 offset provided in ***Notes:***

1. The AMDAR identifier is assigned by the requesting met office.
2. Normal means the data is not compressed. Compressed means the data is encoded using the compression scheme described in Appendix D.
3. Pressure Altitude in ICAO Standard Atmosphere = PALT;
   Barometric Altitude in QNH adjusted atmosphere = BALT;
   If BALT is reported, conversion to the Pressure Altitude (PALT) scale will be necessary in ground processing using runway or area QNH at the time of the observation. This is essential before data can be used or exchanged. If both PALT and BALT are available, PALT is preferred.
4. Departure and Arrival airport are represented by their ICAO code. Reporting of these fields is optional but if available, strongly recommended.

Table 24 and

- Table 25. 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 22 : 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 23 : Header, compressed

Line number	Character number	# of char	Content	Format	Notes
1	1-3	3	AMDAR message version	"A04"	
2	1-26	1 to 26	Optional parameter indication	# or A thru Z	See optional parameters
3	1-7	8	AMDAR aircraft identifier	AAAAAAAA	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	1	altitude reference: pressure altitude (P) or barometric altitude (B)	P or B	3
3	*11-14*	*4*	*departure airport*	*AAAA*	*4*
3	*15-18*	*4*	*arrival airport*	*AAAA*	*4*

Notes:

5. The AMDAR identifier is assigned by the requesting met office.
6. Normal means the data is not compressed. Compressed means the data is encoded using the compression scheme described in Appendix D.
7. Pressure Altitude in ICAO Standard Atmosphere = PALT;
   Barometric Altitude in QNH adjusted atmosphere = BALT;
   If BALT is reported, conversion to the Pressure Altitude (PALT) scale will be necessary in ground processing using runway or area QNH at the time of the observation. This is essential before data can be used or exchanged. If both PALT and BALT are available, PALT is preferred.
8. Departure and Arrival airport are represented by their ICAO code. Reporting of these fields is optional but if available, strongly recommended.

Table 24 : Basic Observation Format, compressed

Description	**Type**	**BASE40 OFFSET**	**Absolute range**	**Delta allowed range**	**Characters**	
					First obs	Subseqobs
phase of flight 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	0	0 to	0 to	5	3

	9x DELTA	0	2678399 SECONDS INTO THE MONTH	32000 SECONDS		
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
TOTALS					23	19

Table 25 : Optional parameters, compressed

DESCRIPTION	TYPE	BASE40 OFFSET	ABSOLUTE RANGE	DELTA ALLOWED RANGE	CHARACTERS	
					FIRST OBS	SUBSEQOBS
ROLL ANGLE FLAG	10 X CHARACTER	0	N/A	N/A	1	1
EDR	10 X CHARACTER	N/A	N/A	N/A	1+8*	1+8*
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 (TENTH OF DEGREES)	10 X ABSOLUTE	0	0 TO 3590	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	O 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					21+7*	21+7*

* The number of characters depends on whether EDR or DEVG is chosen as the turbulence indicator. If EDR is chosen, it also dependsthe value for EDR. In these totals, DEVG is assumed (2 characters), if EDR is chosen, the total number would be 21+7 = 28