International Civil Aviation Organization

Middle East Regional Monitoring Agency Board

Sixteenth Meeting (MIDRMA Board/16)
(Amman, Jordan, 14 – 16 January 2020)

Agenda Item 4: RVSM Monitoring and related Technical Issues

ADS-B GEOMETRIC HEIGHT DATA FOR MONITORING AIRCRAFT HEIGHT-KEEPING PERFORMANCE

(Presented by MIDRMA)

SUMMARY

With endorsement of the ADSB Height Monitoring methodology by the ICAO Separation and Airspace Safety Panel (SASP), ADS-B data can be used for calculating the Altimetry System Error (ASE) which is a measure of the height-keeping performance of an aircraft. It is an ICAO requirement that aircraft operating in RVSM airspace must undergo periodic monitoring on height-keeping performance. The existing methods to estimate aircraft ASE include use of a portable device, the Enhanced GPS Monitoring Unit (EGMU), and ground-based systems called Height Monitoring Unit (HMU) /Aircraft Geometric Height Measurement Element (AGHME). The use of ADS-B data for height-keeping performance monitoring, on top of providing enhanced and alternative means of surveillance, will provide another option for height monitoring keeping performance as per ICAO Annex 6 Part 1 requirement. States are encouraged to provide access to ADS-B data to MIDRMA to support the height-keeping performance monitoring for RVSM approved aircraft registered within and outside the ICAO Middle East region.

Action by the meeting is at paragraph 3.

REFRENCES

- ICAO Annex 6 Part 1
- ICAO Doc 9574
- ICAO Doc 9937

1. INTRODUCTION

1.1 Altimetry System Error (ASE) is a measure of the height-keeping performance of an aircraft. In airspace where RVSM applied, the importance of accurate aircraft height-keeping performance is magnified. Aircraft use a barometric altimeter to determine height and follow common pressure levels in RVSM airspace. The errors in the aircraft altimetry sensing systems are not apparent during routine operations as the altimeter displays to the aircrew and Air Traffic Control a flight level which contains the ASE. Due to the existence of aircraft ASE, the observed flight level by the pilot and ATC is different than the actual height of the aircraft.

1.2 The altimetry system utilizes parts that can wear over time (e.g. the pitot-static probe); can be damaged (e.g. skin flexing/deformation during operations); and can be effected by modifications made to the airframe (e.g. the application of paint or mounting of accessories in the vicinity of the static pressure port). These activities can affect the aircraft's altimetry system in a negative way, producing a significant error in true height. Other factors from normal operations of high-speed flight such as aerodynamic loading and exposure to ranges of temperature, moisture and contaminants, are also capable of producing significant variation in the sensed pressure of the altimetry system. Since the ASE is not detectible in routine operations; ICAO adopted two methods to measure aircraft ASE, either by the Enhanced GPS Monitoring Unit (EGMU) or by the Height Monitoring Unit (HMU)/ Aircraft Geometric Height Measurement Element (AGHME) and recently another method was adopted to measure aircraft ASE which is by the use of geometric height data from **ADS-B** systems.

1.3 The ICAO Separation and Airspace Safety Panel (SASP) first considered the use of geometric height data from ADS-B systems in 2001. While further consideration was given to this issue by SASP in the intervening years, activity was started in earnest following work after significant progress was made with test flights conducted by the United States FAA in 2008 and early 2009 which demonstrated that aircraft geometric height data obtained from ADS-B is sufficient for estimating aircraft Altimetry System Error (ASE).

1.4 Further activities being undertaken through a formal research project between the Federal Aviation Administration (FAA) of the United States and Airservices Australia represented by the Australian Airspace Monitoring Agency (AAMA). This research was aimed at post-processing large ADS-B data sets obtained from extensive ADS-B networks, using programs developed by the FAA that currently process data from and the Enhanced GPS Monitoring Unit (EGMU) to calculate aircraft ASE. The results have been very encouraging. Establishing the validity of using ADS-B geometric height to calculate ASE will provide a highly efficient, wide area monitoring system with little operational impact to aircraft operators or flight crews.

2. DISCUSSION

2.1 Two big advantages of sourcing aircraft geometric height data from ADS-B transmissions are: data collection is passive and does not require any special arrangement with the aircraft operator provided aircraft follow the monitoring requirements or interaction with the flight crew and; the geographical region over which flights can be captured is limited only by the ground station network. The first means that ASE measurements can be performed as many times as thought necessary with only a processing-time penalty. The geographical range could easily be State-wide or wider since a ground station is a relatively cheap and simple unit which can be co-sited with an existing installation (eg VHF antenna). Usually all ADS-B transmissions received at a ground station from ADS-B equipped aircraft are stored. It is therefore feasible to use this data to monitor aircraft height-keeping performance at the fleet level and to provide a thorough ASE history profile for individual airframes.

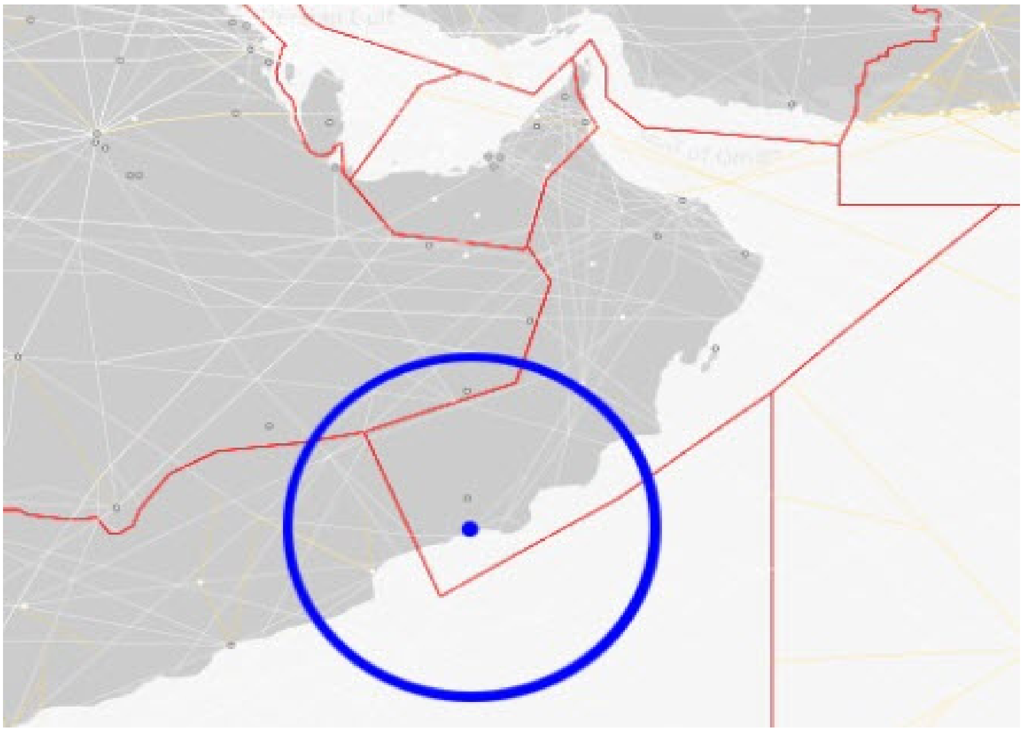
2.2 There is ample information available in an aircraft's detailed ADS-B report history to detect and confirm aberrant or non-compliant Altimetry System Error (ASE) behavior. Systems were established to process a State-wide volume of ADS-B data in order to regularly height monitor all ADS-B equipped aircraft in the State's airspace. The volume of ADS-B data available in States is so large which required certain training to organize the data to facilitate searches and retrievals.

2.3 ADS-B monitoring is undertaken by processing of large data sets of ADS-B messages captured in the coverage area of ADS-B Network. The data is processed to enable the calculation of Altimetry System Errors (ASEs) for each ADS-B message obtained from a specific aircraft or group of aircraft. A final assessed ASE value is then calculated for each observed aircraft.

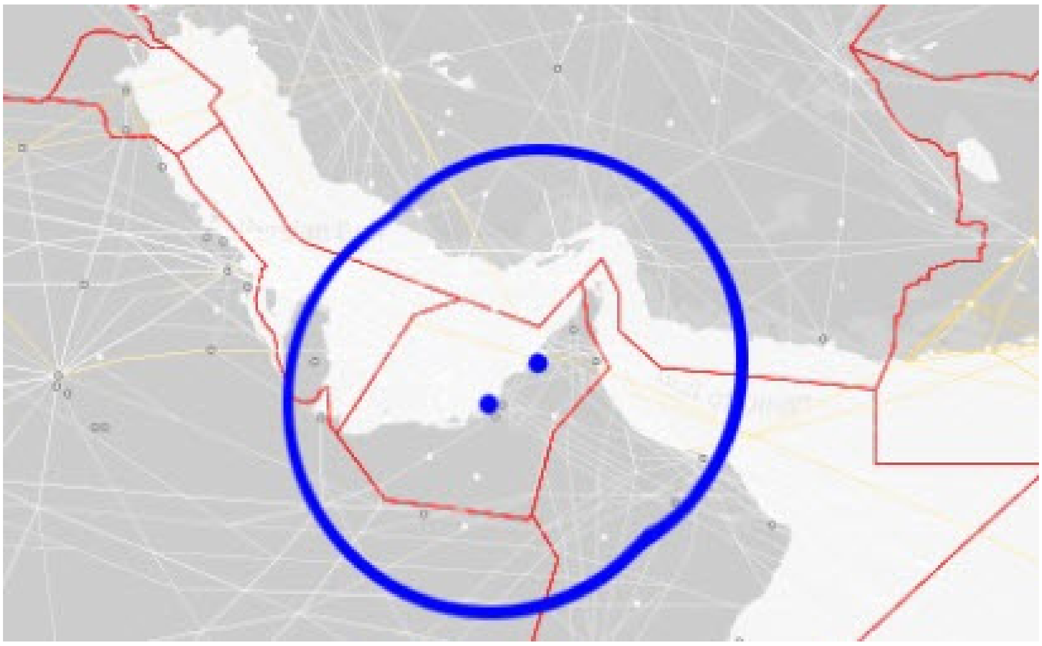
2.4 *Current ADSB Coverage in the Middle East Region*

2.4.1 As far as the MIDRMA aware, ADSB is available for surveillance in parts of Muscat and Khartoum FIRs and in the whole airspace of Emirates FIR with coverage extend parts of their neighboring FIRs.

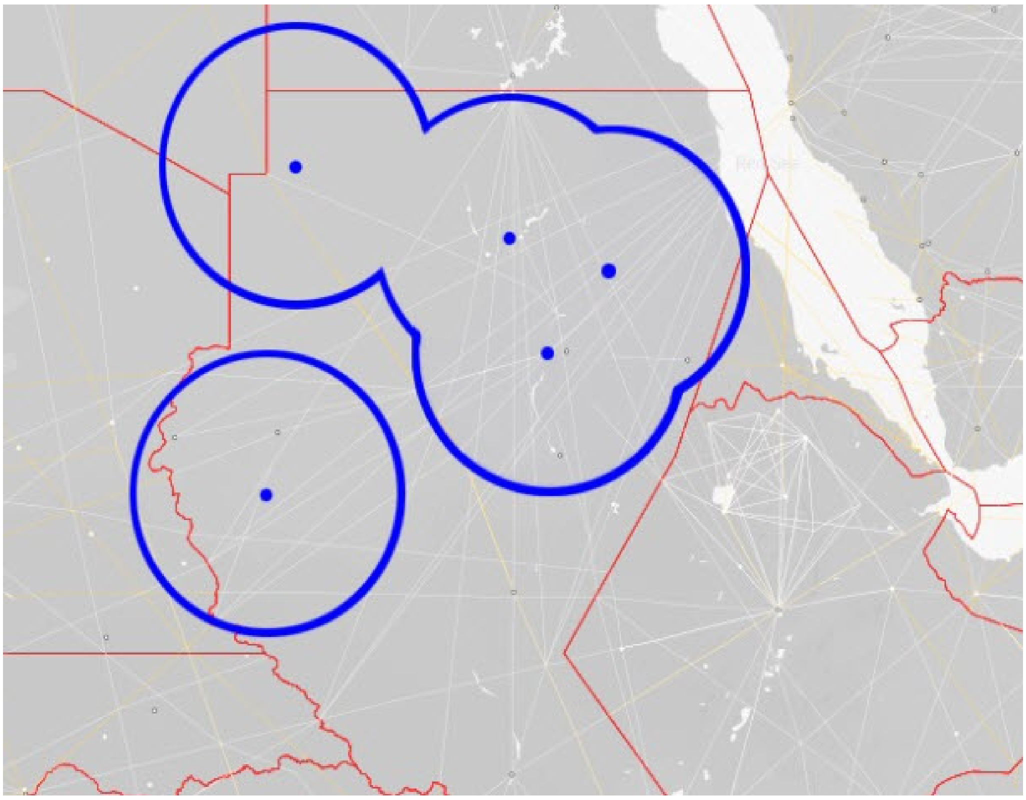
The followings maps reflects the ADSB coverage areas in each FIR:



ADSB Coverage Area in Muscat FIR



ADSB Coverage Area in Emirates FIR



ADSB Coverage Area in Khartoum FIR

2.4.2 The MIDRMA has conducted a statistical study of all RVSM approved aircraft registered in the ICAO Middle East region with a total of 1869 aircraft , and identified 59% of these aircraft that can benefit from ADSB height monitoring and 22% required confirmation from the responsible Airworthiness Authorities of their installed ADSB equipment, this issue will be addressed and coordinated in a later stage, while there is 19% of the Middle East RVSM approved aircraft will not benefit from this type of height monitoring method because these aircraft either not equipped with ADS or not operating within the current ADSB coverage areas in the Middle East region.

2.5 *Methodology*

2.5.1 The method of calculating Altimetry System Error using ADS-B data that all aircraft tracks received at each ground station are processed through the FAA ASE software. The programs are adapted from the AGHME software to facilitate high volumes of data. Periods of flight which are outside RVSM flight levels, non-level or during a turn will be automatically excluded.

2.5.2 The Altimetry System Error software is designed to output a summary of ASE behavior over each track segment. By contrast, the method concentrated on point ASE measurements (which are available in the output files). This approach enabled a better view of the ASE distribution and enabled data from flight segments to be processed as long as the aircraft is in a level flight for the required period of time.

2.5.3 The Altimetry System Error software uses global weather data sets sourced from NOAA (National Oceanic and Atmospheric Administration). Given each ADS-B ground station has a coverage region with radius approximately 200 NM at FL300, flight tracks recorded through ADS-B are longer than those typically observed by HMU, AGHME or GMU. ADS-B reports are transmitted by an aircraft at least once a second. This leads to a very large volume of available data. Despite the difficulties in dealing with such large data sets, no attempt was made to sample the ADS-B data or to otherwise reduce its size.

2.5.4 ASE calculation in ADS-B Height Monitoring System (AHMS) involved several sources of error including a poor local fit to meteorological data, ADS-B height discretization (to every 25 ft) and geoid interpolation. Daily ASE measurements for an airframe vary quite a lot due mainly to 'meteorological error'. However as more data is collected the mean ASE value becomes a robust estimate of ASE. ASE is first represented as an average over all point-time values on a given day. The estimated ASE for an airframe is the mean of these daily averages except where significant trends in the data occur. If a trend in the daily ASE data is observed then linear regression methods are used to estimate the trend slope (in feet per year).

2.5.5 The required ADSB data for RVSM height monitoring must be in form of ASTRIX CAT21 or by using a decoder program to extract the data in ASCll.

2.6 *Using ADS-B Height Monitoring System (AHMS) in the Middle East Region*

2.6.1 It is possible to implement the ADS-B Height Monitoring System (AHMS) in the Middle East Region, but there are many procedures and conditions that must be discussed and agreed upon among the MIDRMA Member States, especially with the authorities using ADSB for surveillance, such as providing MIDRMA the archived ADSB out messages which will be used for calculating the ASE as per the required format.

2.6.2 The archived ADSB out messages must be submitted to MIDRMA in a regular basis and as per the required format and size which will be explained to each ADSB responsible engineer. Extracting the monitoring data which will be used for AHMS from the archived database to meet MIDRMA requirements will require brief explanation and training to ensure the data received is always as per the required format.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) review and discuss the contents of this working paper;

b) encourage States to share their ADS-B data for height monitoring purposes; and

c) decide how to proceed with the implementation of AHMS within the Middle East Region.

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