International Civil Aviation Organization

Middle East Regional Monitoring Agency Board

Fifteenth Meeting (MIDRMA Board/15)
(Muscat, Oman, 29 – 31 January 2018)

Agenda Item 4: RVSM Monitoring and related Technical Issues

ADS-B HEIGHT MONITORING SYSTEM (AHMS)

(Presented by MIDRMA)

SUMMARY

ADS-B Height Monitoring System (AHMS) use ADS-B receivers to obtain geometric height data from ADS-B equipped aircraft. To use this method requires the aircraft to be ADS-B equipped and for the aircraft to fly in a region where ADS-B monitoring is performed.

Action by the meeting is at paragraph 3.

REFERENCES

- Endorsement of AHMS by ICAO Separation and Airspace Safety Panel (SASP) and the Regional Monitoring Agencies Coordination Group (RMACG).

1. INTRODUCTION

1.1 The use of ADS-B as a means to estimate Altimetry System Error (ASE) to comply with ICAO Annex 6 Long Term Height-keeping Monitoring Requirements has been endorsed by ICAO following extensive joint research by Australia Airspace Monitoring Agency (AAMA) and the United States Federal Aviation Administration (FAA). With the global implementation of long term height monitoring requirements such a system provides a significantly low cost, efficient means to undertake long-term height-keeping monitoring without any operational impact on ADS-B equipped aircraft.

1.2 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. DISCUSSION

2.1 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.

2.2 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.

2.3 Since the ASE is not detectible in routine operations, specialized measurement equipment is necessary to independently measure the errors. If an aircraft is unable to maintain its desired altitude relative to others, it poses a greater threat to the other aircraft in the system. Therefore, the ICAO developed standards that individual aircraft and aircraft groups must meet in order to operate in RVSM airspace. An individual aircraft must maintain an airworthiness approval, which states that the aircraft can maintain an ASE value of 245 ft or less.

2.4 On the basis of the research completed and the outcomes provided over a number of years, both the SASP and RMACG have endorsed the use of ADS-B as a height monitoring system. Australia Airspace Monitoring Agency (AAMA) now the pioneer of implementing this system within its airspace.

2.5 Further GPS systems report geometric height as either height above the WGS-84 ellipsoid (HAE) or height above mean sea level (HAMSL). Either is valid since they are both approximations to an ideal Earth surface. However, for the precision required to measure ASE, it is essential to determine which height datum an aircraft GPS uses, HAE or HAMSL.

2.6 The ADS-B Height Monitoring System (AHMS) uses the calculation of ASE involves 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) and the most appropriate ASE value.

2.7 ADS-B allows equipped aircraft to automatically broadcast their position, velocity, and other information with each other and with air traffic controllers. ADS-B equipped aircraft use an on-board Global Positioning System (GPS) receiver to determine their position, this time-stamped information is then broadcast along with other aircraft information to all ADS-B capable aircraft and to ADS-B ground or satellite communications receivers. These receivers then forward the information to Air Traffic Control (ATC) centers. The ADS-B reports includes aircraft geometric height, which is a key component in the ASE estimation process.

2.8 The geometric height obtained from the EGMU is differentially corrected prior to the ASE calculation. This means that much of the position errors are removed from the GPS-derived geometric height with further processing. The GPS-derived geometric height contained in the ADS-B message is not differentially corrected. It is not possible to post-process these geometric heights because the information needed to correct the errors is not included in the ADS-B messages. Some conditions have changed since the initial determination of suitability of uncorrected GPS pseudo-ranges. First, aircraft grade GPS receivers have improved markedly and being capable of tracking more satellites simultaneously. Additionally, the Selective Availability (SA) feature of the GPS system has been completely disabled to the point where non-precision approaches can be attempted with its course guidance. These changes in conditions mean that better accuracy can be expected in the geometric height determined from the modern receivers.

2.9 Some modern receivers have the ability to use the Wide Area Augmentation System (WAAS). WAAS is an air navigation aid developed by the FAA with the goal of improving the GPS position accuracy, integrity, and availability. Augmentation messages are created at the WAAS Master Station (WMS) which allows GPS receivers to remove errors in the GPS signal. However, it is not possible to determine whether WAAS corrections were applied to ADS-B aircraft geometric height data unless it is known that the airframe is equipped with WAAS – this information is typically not available.

2.10 The ASE software was developed which requires aircraft geometric height data, actual flight level (altimetry reading) data, intended flight level for the flight segment and an independent source for meteorological data. Prior to producing estimates of aircraft ASE, the ADS-B data were reformatted and preprocessed to remove unnecessary data fields. The ASE processing begins with the identification of unique straight and level flight segments for each flight observed in the data. A straight and level flight segment is defined by a constant flight level (altimetry reading – Mode S) and without turns. Each straight and level flight segment is considered to be an independent observation. It is possible for the same flight/aircraft operation to have more than one straight and level flight segment in the data as aircraft routinely climb or descend to different flight levels and make turns while in cruise. The ADS-B derived aircraft geometric heights which are quantized to 25 ft are smoothed to reduce any random noise and remove some of the effect of the quantization. The smoothing method used is a nonparametric regression based on the maximum likelihood estimation of a signal-in-noise model.

2.11 Australia Airspace Monitoring Agency (AAMA) offered the MIDRMA to give the ASE software for free but will require extensive training , the MIDRMA proposed to AAMA to deliver the training in Bahrain with the presence of Euro RMA who requested to join the training as well.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) review and discuss the contents of this Working Paper;

b) agree that the ADS-B Height Monitoring System (AHMS) would be used for height-keeping performance monitoring in the MID Region; and

c) encourage States to share their ADS-B data for height monitoring purposes.

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