China RMA Long-term Height Monitoring Program

China Regional Monitoring Agency (China RMA)

www.chinarma.cn

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Dear All,

We apologize for the absence to this ASE Workshop, but we want to use this presentation to introduce China RMA’s progress in promoting long-term height monitoring program, and we also want to take this opportunity to raise some problems and suggestions for your consideration.

We wish this workshop to be very successful! Thank you for all your efforts!

China RMA
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2. Introduction to China RMA’s On-board Monitoring System
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Long-term Height Monitoring Program

- The need for RVSM Monitoring

The errors in the aircraft altimetry sensing systems are not apparent during routine operations as the altimeter displays to the aircrew and air traffic services (ATS) a level that includes these altimetry system errors (ASE).

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Diagram:
- Actual Altitude
- Displayed Altitude
- Transpondered Altitude (Mode C)
- Assigned Altitude Deviation (AAD)
- Assigned Altitude
- Total Vertical Error (TVE)
- Altimetry System Error (ASE)
- Flight Technical Error (FTE)
- Correspondence Error
The need for RVSM Monitoring

As such, the presentation to the pilot and/or ATS is often different to the actual height of the aircraft. During routine calibration the aircraft systems are maintained on the ground while at rest, so the dynamic nature of ASE is not able to be seen.
Long-term Height Monitoring Program

The need for RVSM Monitoring

Aircraft altimetry systems also utilize parts that:

- wear over time (such as the pitot-static probe and portions of internal plumbing); and/or
- are subject to damage (such as skin flexing/deformation during operations); and/or
- are affected by modification of airframes (such as the application of paint, decals and branding marks or mounting of accessories or repairs such as boiler plating in the vicinity of the static pressure ports).

All these activities are capable of producing significant error in true height.
Long-term Height Monitoring Program

- The need for RVSM Monitoring
  ASE can vary over the population of operational aircraft of the same type and within each specific aircraft this error can vary with time in service.
Long-term Height Monitoring Program

- Continued safe RVSM operations demand continuous high accuracy from altimetry systems
- Additional provisions were included in Annex 6 effective November 2010 to ensure that global monitoring requirements were clearly defined. Additionally, amendments to Annex 11 have also been made that clarify regional monitoring responsibilities.

7.2.7 The State of the Operator that has issued an RVSM approval to an operator shall establish a requirement which ensures that two aeroplanes of each aircraft type grouping of the operator have their height keeping performance monitored, at least once every two years or within intervals of 1 000 flight hours per aeroplane, whichever period is longer. If an operator aircraft type grouping consists of a single aeroplane, monitoring of that aeroplane shall be accomplished within the specified period.
Long-term Height Monitoring Program

 Asia Pacific Region Long-term height monitoring Program:

5.1 The implementation of long-term height monitoring requirements has placed significant additional responsibilities on operators, State approval authorities and RMAs alike. Within the Asia/Pacific Region, the RMAs in conjunction with the RMACG, RASMAG and APANPIRG have standardised on a set of RVSM MMRs that reflect the Annex 6 minimum requirements for long term monitoring, and support the intent of the Annex 11 requirements for the establishment of adequate monitoring programs.
Introduction to On-board Monitoring System

- China RMA has two EGMU and two E²GMU
Introduction to On-board Monitoring System

Total Vertical Error (TVE)

Altimetry System Error (ASE)

Flight Technical Error (FTE)

Correspondence Error

Assigned Altitude Deviation (AAD)

Assigned Altitude

Transponder Altitude (Mode C)

Displayed Altitude

Actual Altitude

EGMU

E^2GMU
Introduction to AHMS

- **AHMS** = ADS-B Height Monitoring System

- Advantages of using AHMS:
  - provide large volumes of data and information about the aircraft population and permit repeated measurements on individual airframes, which is highly beneficial in detecting trends in ASE performance
  - provide the continuous data streams necessary to determine aircraft group performance and ASE stability

**Compared to**

- **On-board Monitoring system**: EGMU monitoring addresses the basic MMR, it should be considered only as supplementary to ground-based monitoring
Introduction to AHMS

AHMS

**ADS-B message:** GPS-derived geometric height

**Calculation Method:**
- Total Vertical Error (TVE)
  - Altimetry System Error (ASE)
    - Flight Technical Error (FTE)
    - Correspondence Error
    - Assigned Altitude Deviation (AAD)

- ADS-B message: pressure altitude in reference to a standard atmosphere
  - Transpondered Altitude (Mode C)
  - Assigned Altitude
  - Actual Altitude

**Calculated from** pressure altitude in the ADS-B message and the FLOS
Introduction to AHMS

AHMS monitoring process:

1. Extract and process ADS-B data from the ADS-B network each month. ASE calculations will be completed and reviewed to identify any airframes that may be indicating height-keeping errors close to or exceeding acceptable limits.

2. Notify relevant State authorities of aircraft that demonstrate aberrant height-keeping capability so that those authorities may take corrective action as required by provisions of Annex 6.

3. Provide report to operators and regional CAAs, and publish monitoring information on the security website on a three-month basis.

4. Provide ADS-B monitoring results using the agreed data format to other Regional Monitoring Agencies (RMAs)
Introduction to AHMS

ASE Calculation process

Domestic ADS-B Data

ADS-B Data

GPS Track

Mode C Track

Smoothed Mode C Track

Points AAD

Points TVE, ASE

Mean TVE, AAD and ASE

Geoid Data

Mete Data

MSL Pressure Assigned Flight Level

MSL Geometric Assigned Flight Level

WGS Geometric Assigned Flight Level

Geoid reference
Introduction to AHMS
Geoid reference determination

Geoid Assumption:

1. An aircraft will transmit geometric height as either HAMSL or HAE, depending on the GPS receiver. However, it is often not known which of these geoid assumptions is being used prior to our analysis and it must be determined from the ASE data.

2. The following figure shows the contours of the difference between HAMSL and HAE overlaid on a map of Australia. These are contours of the separation between the Earth’s geoid and the WGS 84 ellipsoid, referred to here loosely as ‘geoid contours’. A contour of 150 ft means HAMSL=HAE+150 ft. The variation in the figure is from roughly -100 ft to 200 ft. The zero contour when HAMSL = HAE heads North-West from Tasmania. An aircraft traveling a route such as Perth to Cairns (SW to NE) would cross approximately 300 ft of geoid contours which is useful in evaluating an aircraft’s geoid assumption.
Introduction to AHMS

Geoid reference determination

Geoid Assumption:
Introduction to AHMS

ASE Data Analysis Software platform snapshot
Introduction of Analysis Plot

- **Analysis Plot**
  - ASE Daily mean chart
  - ASE Distribution fitting chart
  - ASE Geoid compare chart
  - Flight Track

**Altimetry System Error Analysis for Aircraft hx78xxxx**

- Aircraft: hx78xxxx
- Geoid Reference: HAE
- Whole Daily Slope: -0.0147
- Data Comment: Split Data Used
- Final ASE: -196.4901 ft.
- ASE Range: [-225.0115, -105.4319]
Introduction of AHMS

- ADS-B Monitoring Report
  - Monitoring report for operators
  - Aberrant report
  - Non-compliant report

- Data Sharing
  - Share ADS-B Monitoring results with other RMAs
  - ADS-B monitoring results on request for operators outside China RMA’s responsible area

ADS-B monitoring results can help operator to meet the Long-term height monitoring requirement.
How to get an aircraft ADS-B monitored in China

- Aircraft is ADS-B-equipped (ADS-B out)
- ADS-B function is enabled all the time during the flight in Chinese RVSM airspace
- Aircraft fly over ADS-B ground stations and maintain straight and level flight for a period of time
- Aircraft are able to broadcast messages to ADS-B ground stations
Route coverage of ADS-B ground stations applied by China RMA
Data has transferred to Beijing Center

Data has not transferred to Beijing Center
The reason to maintain a live monitoring burden list on-line is to provide the operators and responsible CAA inspectors with the progress for each operator-monitoring group meeting the long-term height monitoring program, so that both the operator/inspectors and the China RMA can have a better coordination for the arrangement of monitoring schedule.
Issue of Monitoring Burden

- Where: China RMA on-line data-exchange platform (user security website): www.chinarma.cn/CRMA
- Update frequency: at least once a month
- What you can get from the monitoring burden:
  - no. of registered aircraft under each monitoring group,
  - the regno for aircraft that have valid monitoring records,
  - no. of aircraft to be monitored under each monitoring group
Issue of Monitoring Burden

How to produce the monitoring burden list

Monitoring Burden is produced on the basis of:

- all the available valid monitoring records (China RMA’s and KSN-shared)
- Latest RVSM approval database maintained by China RMA
- Latest MMR table updated by RMACG
Issue of Monitoring Burden
Coordination with regulators

- Draft of RVSM China Long-term Height Monitoring Guidance
- Update of RVSM operational management procedure to incorporate requirement for long-term height monitoring
Problems and Suggestions

Suggestion 1: ICAO should raise the attention of State regulators to the importance of long-term height monitoring, and relevant procedures should be in place for non-compliance with monitoring requirement. A good example is the requirement in Doc 034 in Europe, and State should take more active actions.

Problems: RMAs promoted the LTHM program very actively, but still a number of operators don’t get their aircraft monitored and no further actions taken by states.
Problems and Suggestions

Suggestion 2: RMAs may consider to establish an ASE case study database to accumulate typical ASE problems and remedial actions together. This database can be very helpful for RMAs, operators and other relevant stakeholders to understand ASE problem, and learn from others good experience to improve altimetry system.

Problems: each individual RMA may not meet all the ASE problems, and may lack experience to give suggestions to some special ASE cases. There is no guidance for ASE causes and remedial actions. The only material that touch this point is RMACG/8 Flimsy 4 by Mr. Phil Evans.
Problems and Suggestions

Suggestion 3: RMAs may establish a channel to share large ASE problem with manufactures to raise their attention.

Problems: with time goes by, some monitoring groups begin to demonstrate increased rate of ASE deterioration. RMAs compare data with each other for this problem. If it is determined as a group error, it should draw the attention to manufactures immediately.
Problems and Suggestions

Suggestion 4: With the development of ADS-B technology and application of DO-260A, DO-260B, there should be new criteria for data quality assurance of AHMS system.

Problems: when processing DO-260 data, RMAs use the NUC value to filter the data of good quality. But when processing DO-260A and DO-260B data, the NUC value is replaced with several other parameters. RMAs should pay attention to its influence to the AHMS system and consider the new criteria for data quality assurance.
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