International Civil Aviation Organization

THE EIGHTH MEETING OF THE SOUTHEAST ASIA AND BAY OF BENGAL SUB-REGIONAL ADS-B IMPLEMENTATION WORKING GROUP (SEA/BOB ADS-B WG/8)

Yangon, Myanmar 5 - 7 December 2012

Agenda Item 5: Need for monitoring and improvement in compliance

USE OF BAROMETRIC ALTITUDE AND GEOMETRIC ALTITUDE INFORMATION IN ADS-B MESSAGE FOR ATC APPLICATIONS

(Presented by Hong Kong, China)

SUMMARY

Currently, both information on barometric altitude and geometric altitude are categorized as operationally desirable items and will be downlinked, together with other ADS-B information, from aircraft to ATM automation system. This paper highlights the technical differences between barometric altitude and geometric altitude, and recommends States/Administrations to duly consider safety implications in processing and displaying altitude information by ATM automation system for use by air traffic control (ATC).

1. INTRODUCTION

1.1 According to the "Guidance Material on Generation, Processing and Sharing of ASTERIX Category 21 ADS-B Messages" endorsed by APANPIRG/23, both "Flight Level" (I021/145) and "Geometric Altitude" (I021/140) data items contained in Asterix Category 21 ADS-B messages are categorized as operationally desirable items which should always be transmitted to air traffic management (ATM) automation system for processing whenever the data are received by ground stations from aircraft.

1.2 "Flight Level" data item is the barometric altitude derived from on-board pressure altimeter, and is the same as Mode C code transmitted by an ATC transponder when being interrogated by a SSR. An ADS-B equipped aircraft could transmit both barometric altitude and geometric altitude to ground stations. It is therefore essential to understand differences between these two altitude information contained in ADS-B message so as to ensure safe and efficient use of them for various ATC applications.

2. DISCUSSION

2.1 Barometric Altitude

In civil aviation, on-board altimeters based on barometric pressure have been used to measure aircraft altitude from the mean sea level (MSL). The on-board altimeter is calibrated to indicate pressure as an altitude in feet or meters. The calibration assumes that pressure drops at a standard rate as altitude is increased, and makes reference to either the International Standard Atmosphere (ISA) (i.e. standard sea level pressure at 1013.25 hPA at 15°C), or the local sea level pressure supplied by ATC (i.e. local QNH), depending on whether the aircraft is above or below the transition altitude. This assumption is not accurate for two major reasons:

(a) If the temperature at sea level is other than 15°C then the rate of drop will be non-standard; and
(b) The atmosphere usually has a mix of hot and cold layering making the rate of change of pressure non-uniform.

To avoid human errors, barometric altitude transmitted by aircraft to ground stations always makes reference to the ISA. Depending on whether the aircraft is flying above or below the transition altitude, barometric altitude so received will be automatically corrected by the ATM automation system based on local QNH before displaying to ATC.

2.2 Geometric Altitude

GPS geometric altitude is a measure of the vertical distance between an aircraft and the MSL. This is the height information calculated by the on-board GPS receiver based on a constellation of at least 4 GPS satellites, and is broadcasted to ground stations via ADS-B. However, GPS uses WGS84 ellipsoid as an approximation to the MSL, which could have errors between -100m and 70m with respect to the geoid, depending on location on the globe. The geoid is the best definition of the MSL, which is used as the reference for pressure altitude.

Altitude measurement of GPS is less accurate than its horizontal position measurement. Error in geometric altitude is typically 3 times more than that for horizontal position, and is usually contained within 30-50m unless under poor satellite constellation. Currently, geometric altitude is used as a means to estimate altimeter system error (ASE) of an aircraft in height-keeping performance monitoring, and is not used for ATC purpose.

2.3 Differences between Barometric Altitude and Geometric Altitude

As GPS and a pressure altimeter are measuring two fundamentally different quantities, even if the measuring instrument is absolutely accurate the two altitude data will generally not agree with each other, except under the circumstances that the atmosphere perfectly matches with the profile assumed in the ISA, and the pressure altimeter has been corrected for the actual sea level pressure. Appendix 1 shows a typical plot on barometric and geometric altitude information transmitted by an ADS-B equipped aircraft departing from the Hong Kong International Airport on a day where local QNH = 1016 hPa and 20°C at sea level. As the aircraft climbs the geometric altitude progressively reads higher than the barometric altitude. About 400 ADS-B equipped aircraft with NUC value > 4 flying within the Hong Kong FIR reaching FL300 have been analysed. It is found that the difference between geometric and barometric altitude at FL300 could range from 1600-2200ft, with an average of 1900ft.

2.4 Processing and Display of Altitude Data from ADS-B Message

With ADS-B it is now feasible for ATM automation system to receive both barometric and geometric altitude from an ADS-B equipped aircraft. However, due to fundamental difference in these two altitude data, geometric altitude shall not be used for air traffic control without a safety assessment being conducted and approved in prior. Upon checking with major equipment suppliers providing ATM automation system, it is revealed that while all systems will process and display barometric altitude by default, some of them do process and display geometric altitude, without any alert/warnings to controllers, in the event that barometric altitude is absent. Despite the fact that probability for an ADS-B equipped aircraft transmitting solely geometric altitude is low, States/Administrations are recommended to implement their ATM automaton system in accordance with the APAC ADS-B Implementation and Guidance Document (AIGD) that:

(a) to process and display only barometric altitude when barometric altitude is present; and

(b) in the event that barometric altitude is absent, geometric altitude could be displayed for situational awareness purpose, but not for aircraft separation. Moreover, an appropriate sign should be indicated against the displayed attitude to duly alert controllers.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

(a) recognize both barometric altitude and geometric altitude will be transmitted by an ADS-B equipped aircraft via ADS-B message;

(b) take note of technical differences between barometric altitude and geometric altitude information from aircraft;

(c) recommend States/Administrations to implement their ATM automaton system in accordance with the APAC ADS-B Implementation and Guidance Document (AIGD) as detailed in paragraph 2.4 above;

(d) seek assistance from the ICAO to promulgate this information to States/Administrations on processing and displaying altitude information; and

(e) seek guidance from the ICAO to address possible safety implications arising from displaying GPS geometric altitude information by ATM automation system.

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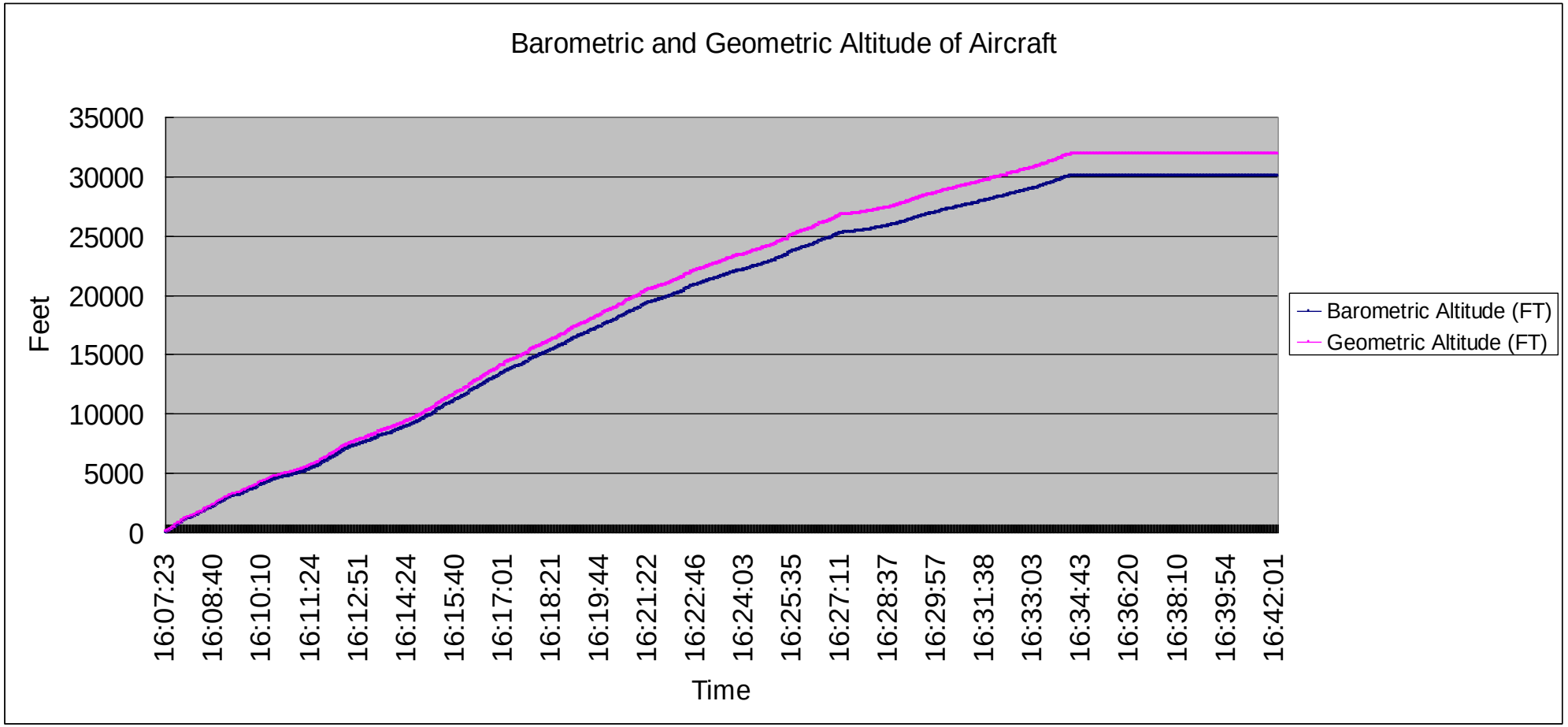
Appendix 1


Barometric and Geometric Altitude of Aircraft
35000
30000
25000
20000
15000
10000
5000
0
Feet
16:07:23
16:08:40
16:10:10
16:11:24
16:12:51
16:14:24
16:15:40
16:17:01
16:18:21
16:19:44
16:21:22
16:22:46
16:24:03
16:25:35
16:27:11
16:28:37
16:29:57
16:31:38
16:33:03
16:34:43
16:36:20
16:38:10
16:39:54
16:42:01
Time
Barometric Altitude (FT)
Geometric Altitude (FT)