

HKP-Performance Monitoring (HKPM) Introduction

中国航空器监控的技术与应用



中国地区监控组织
CHINA REGIONAL MONITORING AGENCY

**China Regional Monitoring Agency
(China RMA)**

29 June 2026



Content

1. Global HKPM Program
2. The need for RVSM Monitoring
3. Minimum Monitoring Requirement(MMR)
4. Height Monitoring Systems



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Global HKPM Program

□ ICAO Annex 11 (Air Traffic Services)— Chapter 3

3.3.5.1 For all airspace where a reduced vertical separation minimum of 300 m (1 000 ft) is applied between FL 290 and FL 410 inclusive, a programme shall be instituted, on a regional basis, for monitoring the height-keeping performance of aircraft operating at these levels, in order to ensure that the continued application of this vertical separation minimum meets the safety objectives. The scope of regional monitoring programmes shall be adequate to conduct analyses of aircraft group performance and evaluate the stability of altimetry system error.



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Global HKPM Program

□ ICAO Annex 6 (Operation of Aircraft)— Chapter 7

7.2.7 The State of the Operator that has issued an RVSM approval to an operator shall establish a requirement which ensures that a minimum of 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.



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Global HKPM Program

□ ICAO Doc 9574 (Manual on a 300 m (1 000 ft Vertical Separation Minimum Between FL 290 and FL 410 Inclusive)— Chapter 5

Responsibilities of State regulatory authorities in the monitoring process

5.4.6 As part of the process to monitor compliance with the global system performance and global height-keeping performance, independent monitoring of aircraft height-keeping performance in a given region may be instigated. The RMA will be responsible for collating and analysing the height-keeping data and, in the event that an RVSM-approved aircraft is monitored with an estimated ASE or TVE in excess of the limits, corrected for system measurement inaccuracy, set out at 5.4.5, will take action to inform both the appropriate State authority and the operator. The State authority will be requested to take action to help the RMA determine the cause of the error. In the event that the investigation reaches an unsatisfactory conclusion, the State authority may consider suspending or revoking the operator's RVSM approval. Following any rectification work, the operator would again be expected to demonstrate compliance with the RVSM MASPS by ensuring that the subject aircraft has been monitored by an independent height-monitoring system at the earliest opportunity.



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Global HKPM Program

□ ICAO Doc 9937 (Operating Procedures and Practices for Regional Monitoring Agencies in Relation to the Use of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive)—FOREWORD

The objectives of the RVSM monitoring programme include, inter alia:

- a) verification that the RVSM approval process remains effective;*
- b) verification that the target level of safety will be met upon implementation of RVSM and will continue to be met thereafter;*
- c) monitoring of the effectiveness of the altimetry system modifications which have been implemented to enable aircraft to meet the required height-keeping performance criteria; and*
- d) evaluation of the stability of altimetry system error (ASE).*



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Global HKPM Program

❑ ICAO Doc 9937 (Operating Procedures and Practices for Regional Monitoring Agencies in Relation to the Use of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive)— Chapter 1

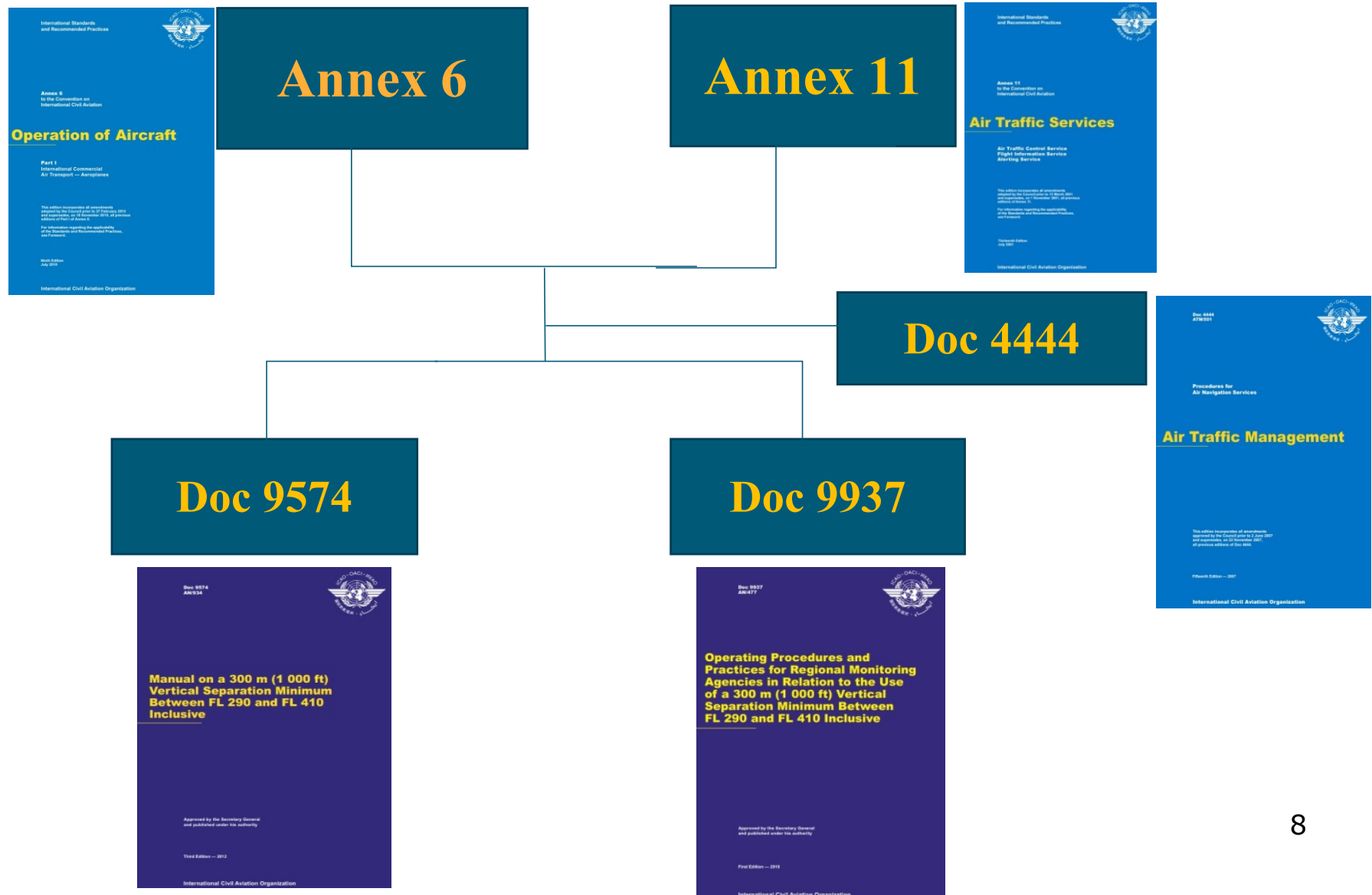
1.2.2 RMA duties and responsibilities are described in Doc 9574, 5.4.4 and 5.4.5, as well as in Appendix A to this manual. For the purposes of this overview, the functions of an RMA can be summarized as:

- a) establish and maintain a database of RVSM approvals;*
- b) monitor aircraft height-keeping performance and the occurrence of LHDs and report the results appropriately;*
- c) conduct safety assessments and report the results appropriately;*
- d) monitor operator compliance with State approval requirements and report non-approved aircraft to the appropriate authority or RMA; and*
- e) initiate necessary remedial actions if RVSM requirements are not met.*



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The need for RVSM Monitoring

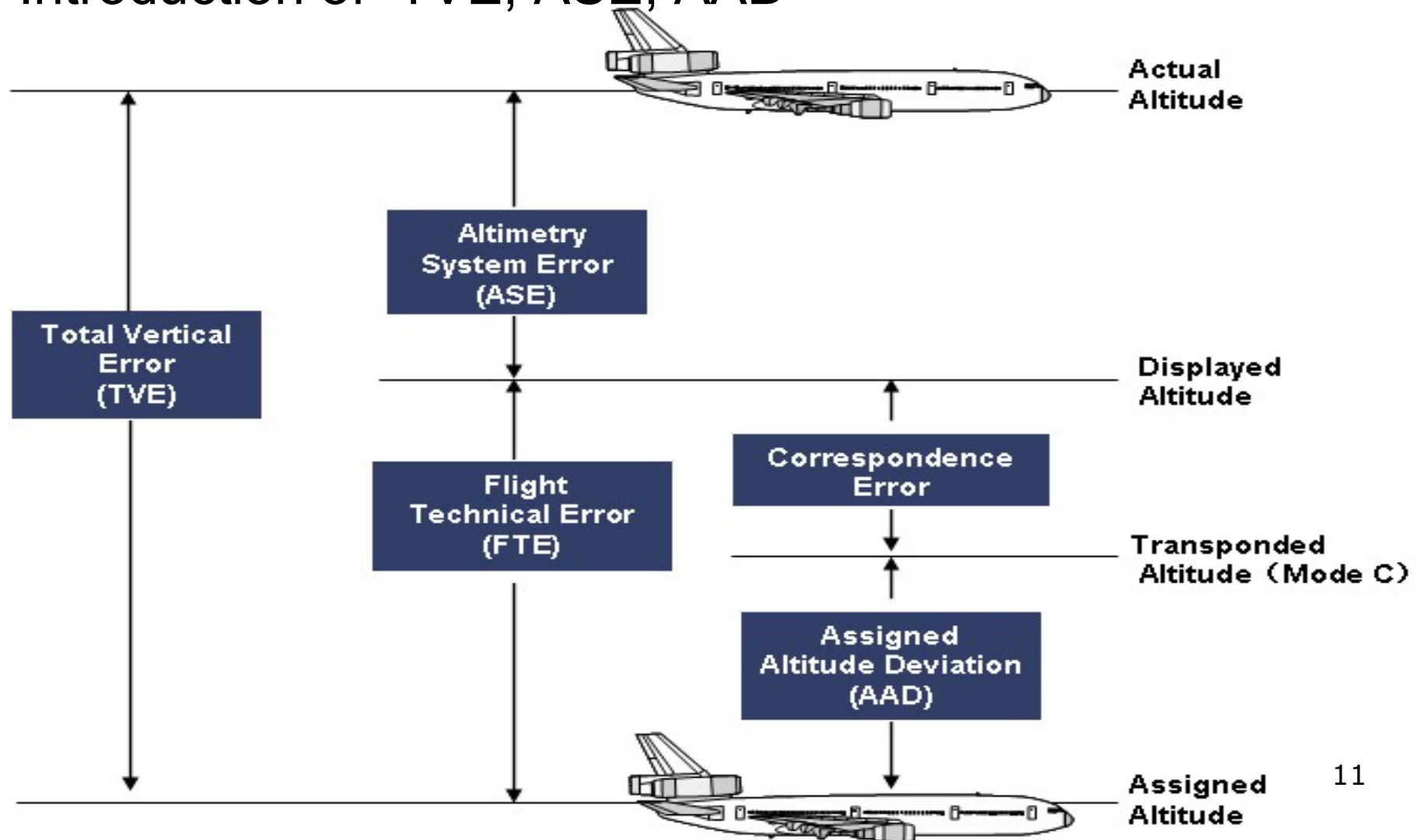
The height keeping performance (HKP) reflects the aircraft's capability to comply with the assigned flight level. The main purposes of conducting aircraft HKP monitoring can be summarized into two points:

- detect potential issues in the altimetry system
- determine the error range of total vertical deviation during aircraft operations in the RVSM airspace, which is used for airspace safety assessment calculations.



The need for RVSM Monitoring

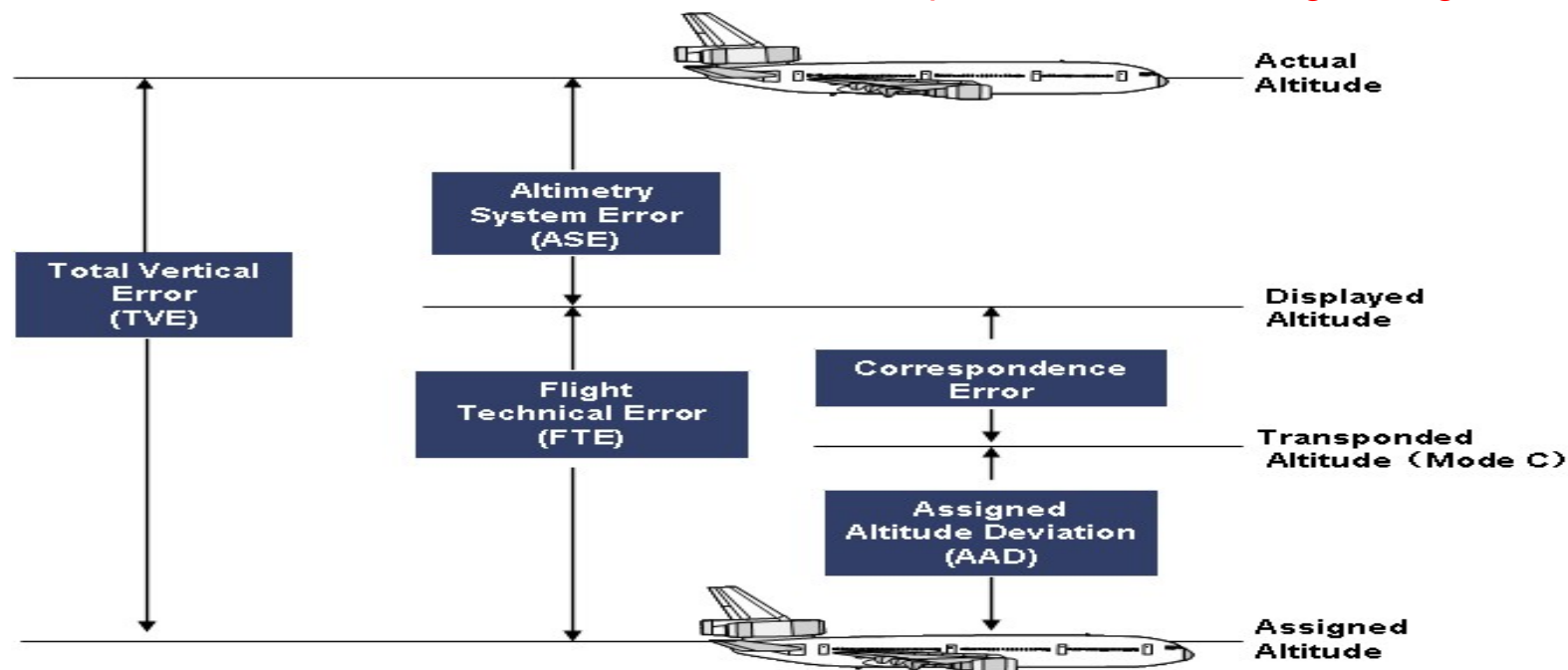
□ Introduction of TVE, ASE, AAD





The need for RVSM Monitoring

- AAD= Displayed Altitude- Assigned Altitude
 - ✓ pilots and air traffic controllers can detect;
- ASE= Actual Altitude- Displayed altitude
 - ✓ pilots and air traffic controllers can not detect;
- TVE= Actual Altitude- Assigned Altitude=ASE+AAD
 - ✓ The difference between the aircraft's actual position and the assigned flight level.





Height Monitoring Systems

Based on the criteria listed in the ICAO Doc 9574 and Doc 9937, for any type of monitoring system, the non-conformance criteria are as follows:

□ Individual aircraft

Non-Compliant

$$|TVE| \geq 300 \text{ ft}$$

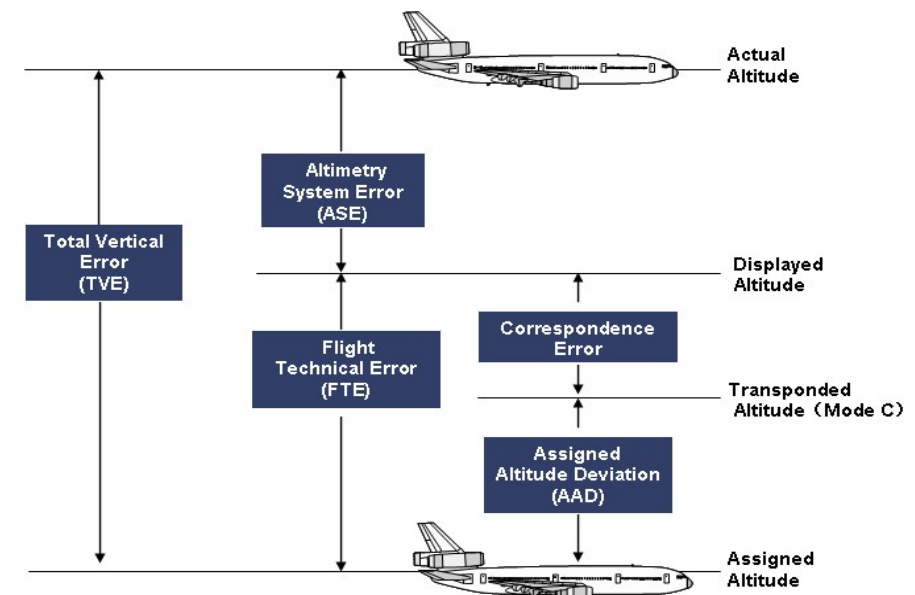
$$|AAD| \geq 300 \text{ ft}$$

$$|ASE| \geq 245 \text{ ft}$$

□ Non-compliant Aircraft Group

$$| \text{mean ASE} | \geq 80 \text{ ft}$$

$$| \text{mean ASE} | + 3 \text{ SD of ASE} \geq 245 \text{ ft}$$





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**.



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Minimum Monitoring Requirement

- ❑ The number of aircraft required to be monitored is dependent upon the monitoring group and category as specified in the [Minimum Monitoring Requirement](#).
- ❑ Due to technological differences and practical implementation constraints, the globally harmonized standard **requires that each state or region perform at least this amount of monitoring**.
- ❑ This **ensures a certain level of confidence** in the fleet represented within the MMR, reflecting the performance level of that particular aircraft type/category.



Minimum Monitoring Requirement

CATEGORY		GROUP DESCRIPTOR	MINIMUM MONITORING REQUIREMENTS
1	GROUP APPROVED: DATA INDICATES COMPLIANCE WITH THE RVSM MASPS	A124, A20N, A30B, A306, A310-GE, A310-PW, A318, A320, A330, A339, A340, A345, A346, A350, A380, A3ST, AVRO, B38M, B39M, B712, B727, B737C, B737CL, B737NX, B747CL, B74S, B744-5, B744-10, B748, B752, B753, B764, B767, B772, B773, B787, B78X, BCS1, BD100, BE40, C25A, C25B, C25C, C510, C525, C550-B, C560, C56X, C650, C680, C750, CARJ, CL600, CL604, CL605, CRJ7, CRJ9, CRJ10, DC10, E135-145, E135BJ1, E135BJ2, E170-190, E290, E295, E545-550, E50P, E55P, F100, F2TH, F900, FA7X, GALX, GLEX, GL5T, GL7T, GLF4, GLF5, GLF6, GLF7, H25B-800, J328, LJ35-36, LJ40, LJ45, LJ60, MD10, MD11, MD80, MD90, PC12, PC24, PRM1, T154, TBM	Operators of aircraft types contained in this category shall have a minimum of 2 airframes monitored every 2 years or 1,000 flight hours, whichever is longer calculated from the date of the last successful height monitoring. Operators with fleets consisting of aircraft from more than one Monitoring Group shall meet this requirement for each group in the fleet. In the event that an operator has a single airframe from a Group, then that aircraft shall be monitored every 2 years or 1,000 flight hours, whichever is longer calculated from the date of the last successful height monitoring.
2	GROUP APPROVED: INSUFFICIENT DATA ON APPROVED AIRCRAFT	Other group aircraft other than those listed above including: A148, A158, A321XLR, A337, AC90, AC95, AJ27, AN72, ASTR, ASTR-SPX, B701, B703, B731, B732, B744-LCF, BE20, BE30, C441, C500, C550-II, C550-SII, C700, C919, D328, DC85, DC86-87, DC91, DC93, DC94, DC95, EPIC, E120, E45X, EA50, F70, FA10, FA20, FA50, FA6X, G150, G280, GLF2, GLF8, GLF2B, GLF3, H25B-700, H25B-750, H25C, HA4T, HDJT, IL62, IL76, IL86, IL96, L101, L29B-2, L29B-731, LJ23, LJ24, LJ25, LJ28, LJ31, LJ55, MC21, MU30, PA46, PA46-701, P180, P180-II, PAY4, SB20, SBR1, SBR2, SF50, SU95, T134, T204, T334, WW24, YK42	Operators of aircraft types contained in this category shall have a minimum of 60% of airframes monitored every 2 years or 1,000 flight hours, whichever is longer calculated from the date of the last successful height monitoring, (the number of airframes to be monitored shall be rounded up to the nearest whole integer). Operators with fleets consisting of aircraft from more than one Monitoring Group shall meet this requirement for each Group in the fleet.
3	NON-GROUP	Aircraft types for which no generic compliance method exists: A225, AN12, AN26, B190, B462, B463, B74S-SOFIA, BA11, BE9L, GSPN, H25A, L29A, PAY3, R721, R722, SJ30, STAR	Operators of aircraft types contained in this category shall have 100% of airframes monitored every 2 years or 1,000 flight hours, whichever is longer calculated from the date of the last successful height monitoring.

Aircraft are considered to be members of the same group if they are designed and assembled by one manufacturer and are of nominally identical design and build with respect to all details that could influence the accuracy of height-keeping performance.

For the same operator, **at least two** of each monitoring group need to be monitored

For the same operator, **at least 60%** of each monitoring group (rounded up in case of decimals) need to be monitored

100% of the aircraft in this group need to be monitored



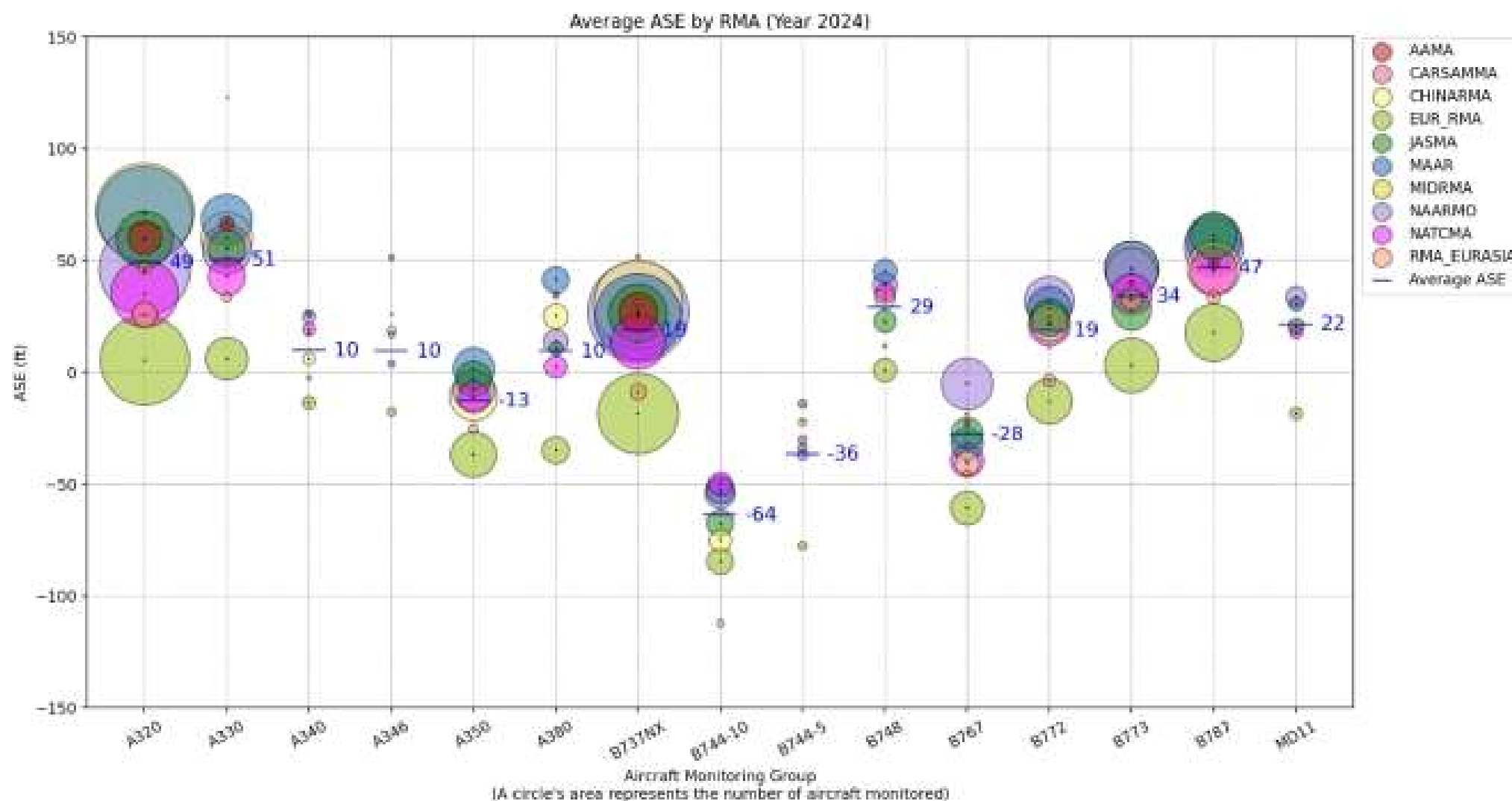
Minimum Monitoring Requirement

- ❑ Operators are required to conduct **initial monitoring within six months** of date of RVSM approval issue and must conduct **monitoring every two years or within intervals of 1,000 flight hours** per aircraft, whichever period is longer.
- ❑ As aircraft are introduced into and withdrawn from operation in different countries, monitoring plans are relatively dynamic.
- ❑ Based on the actual performance monitored by each RMA, the MMR is adjusted and updated at the annual RMACG meeting.



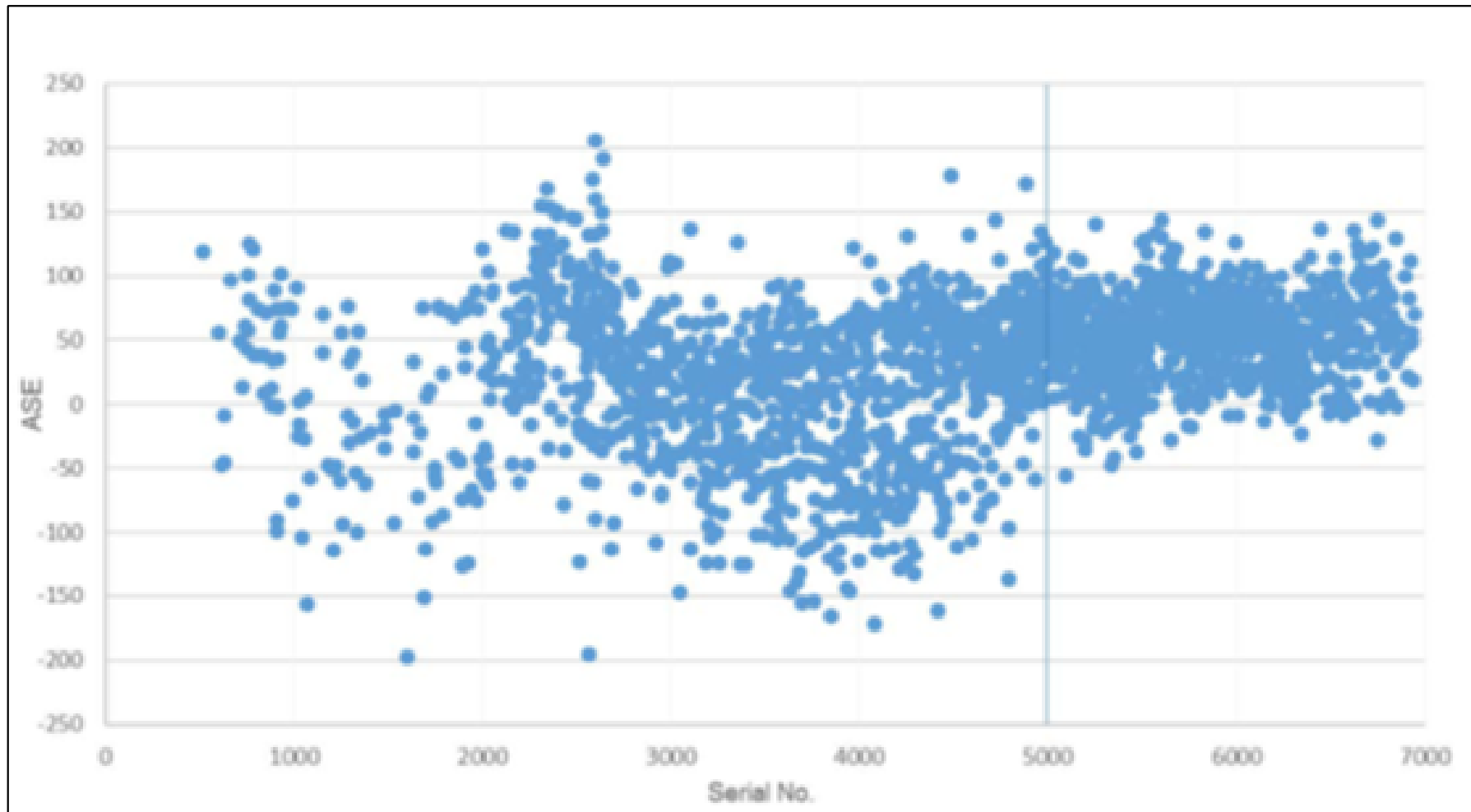
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Minimum Monitoring Requirement





Minimum Monitoring Requirement





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 - a. On-board Height Monitoring System
 - b. Ground-based Monitoring System
 - c. ADS-B Height Monitoring System



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Height Monitoring Systems

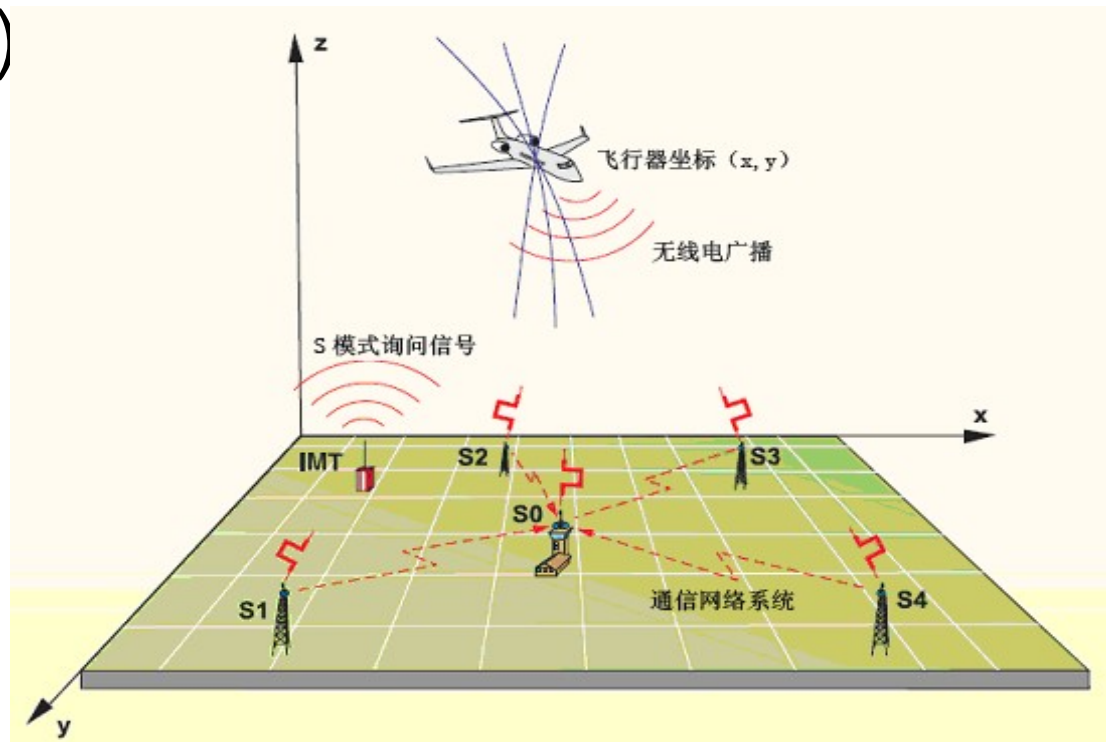
- ❑ **On-board Height Monitoring**
- ❑ Monitoring engineers carry monitoring equipment onboard the aircraft to collect data , then using software to calculate the aircraft's HKP after returning to the ground.
- ❑ The on-board system allows for monitoring to be targeted on aircraft sub-populations, possibly those which have shown to be poor performers





Height Monitoring Systems

- Wide Area Multilateration **Ground-based Monitoring Systems**
 - Height Monitoring Units (HMUs)
 - Aircraft Geometric Height Measuring Elements (AGHMEs)

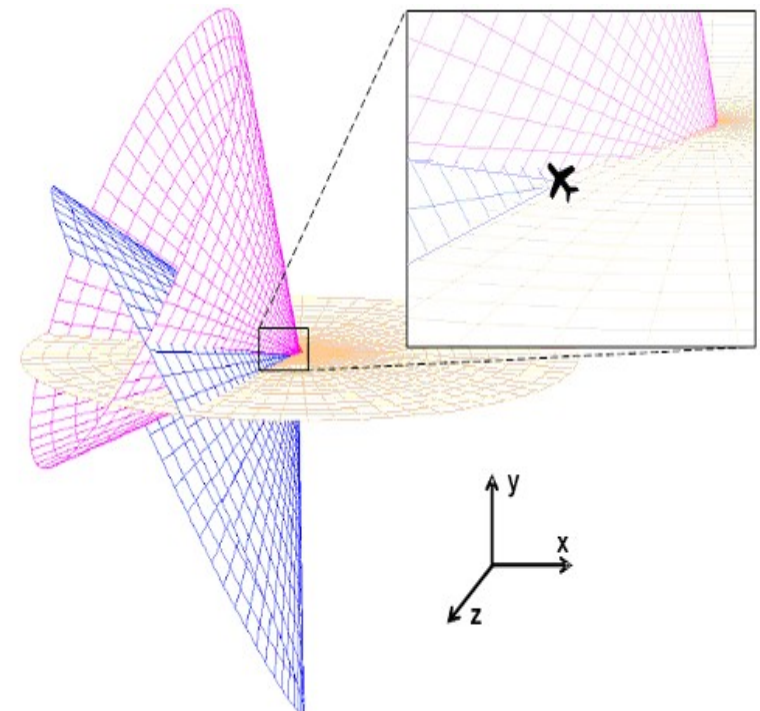


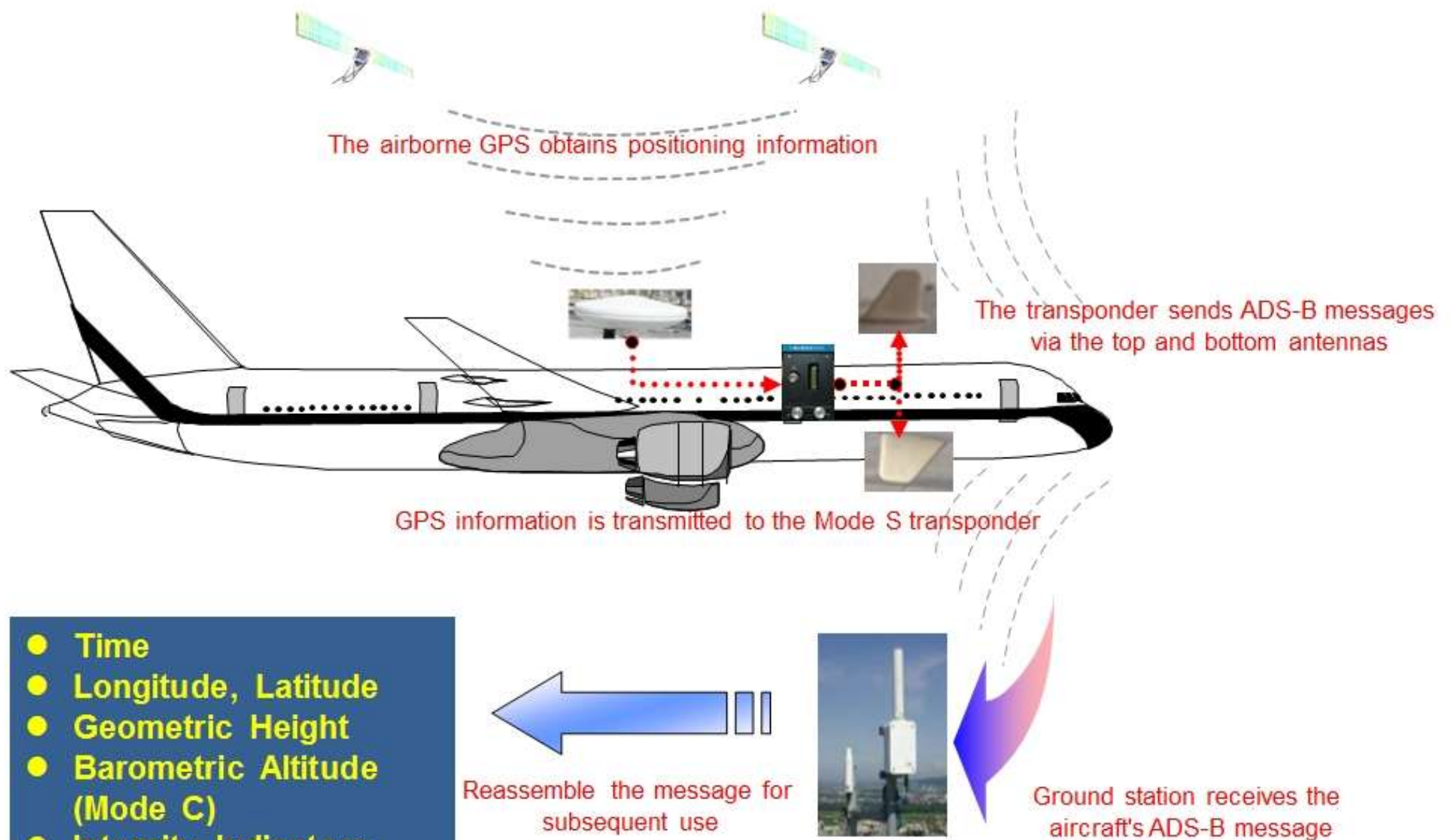


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Height Monitoring Systems

- **AHMS= ADS-B Height Monitoring System**
 - ✓ Aircraft is ADS-B-equipped (ADS-B OUT)
- **Advantages of using AHMS:**
 - provide large volumes of data and information
 - detect trends in ASE performance
 - determine aircraft group performance and ASE stability

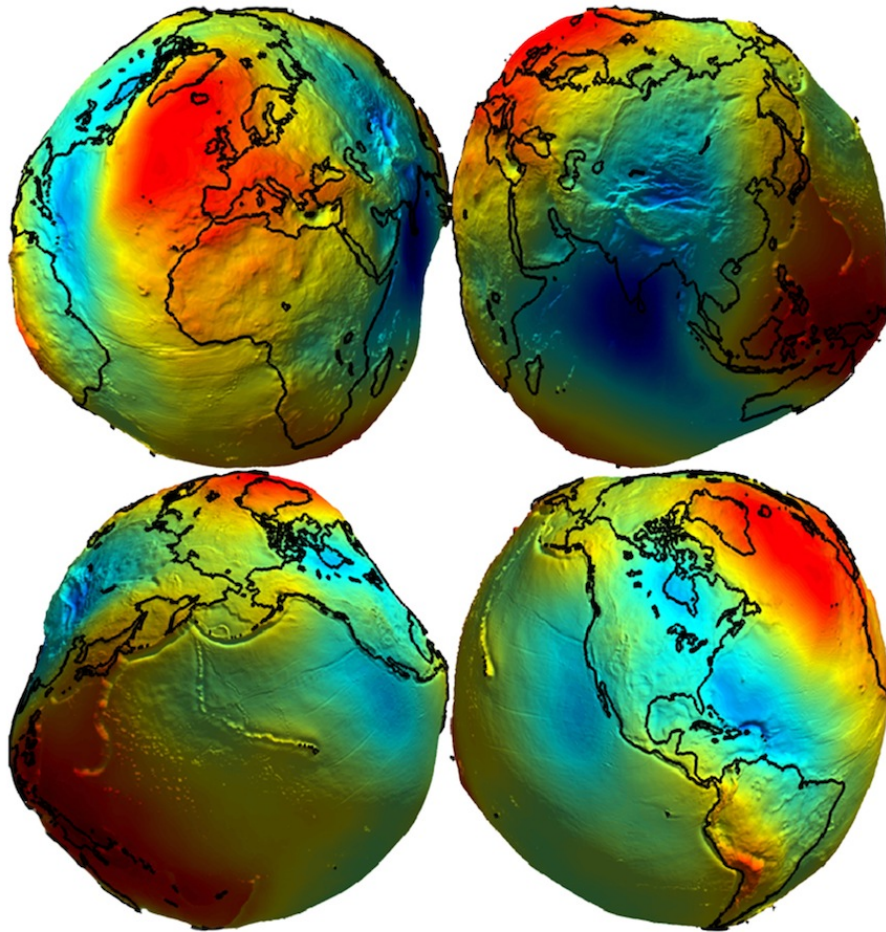




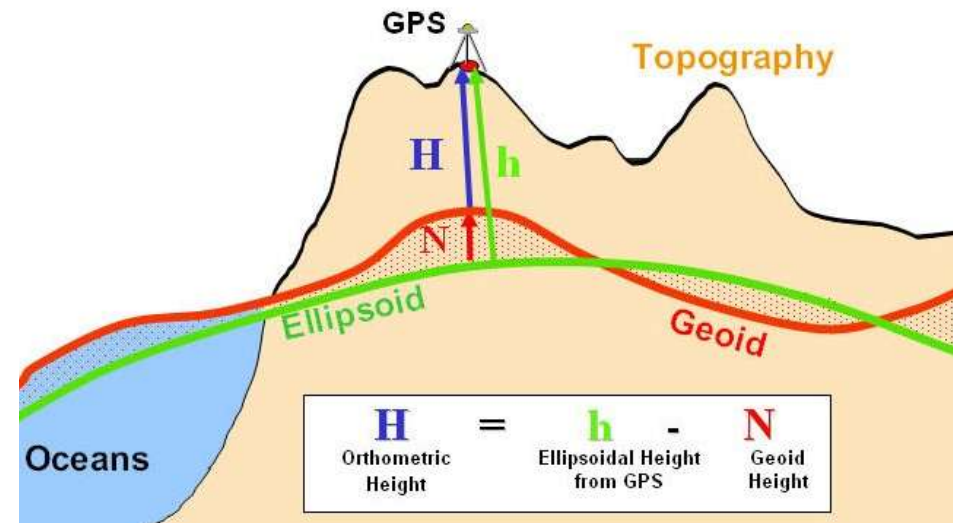
- Time
- Longitude, Latitude
- Geometric Height
- Barometric Altitude (Mode C)
- Integrity Indicators (NUC, NAC)



Height Monitoring Systems

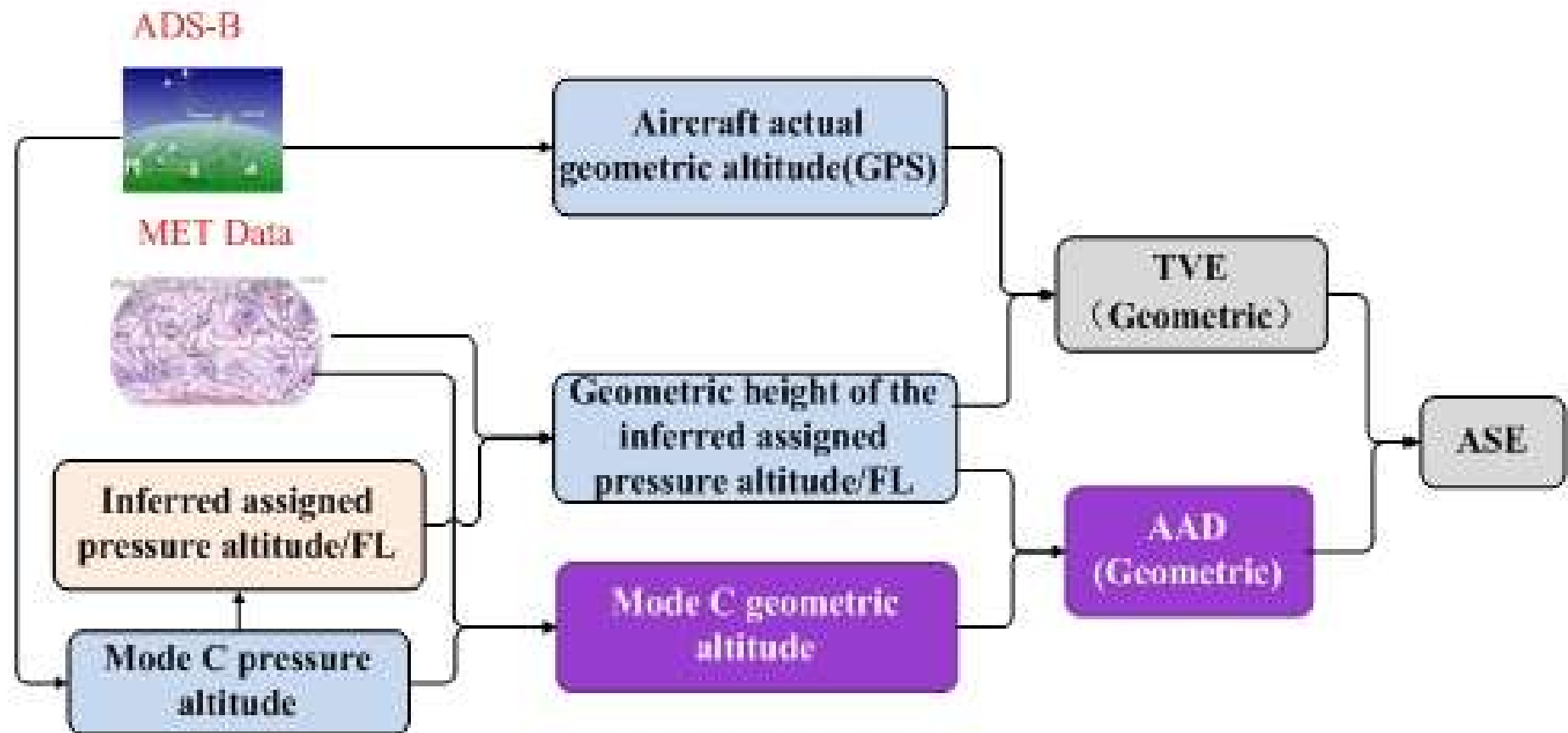


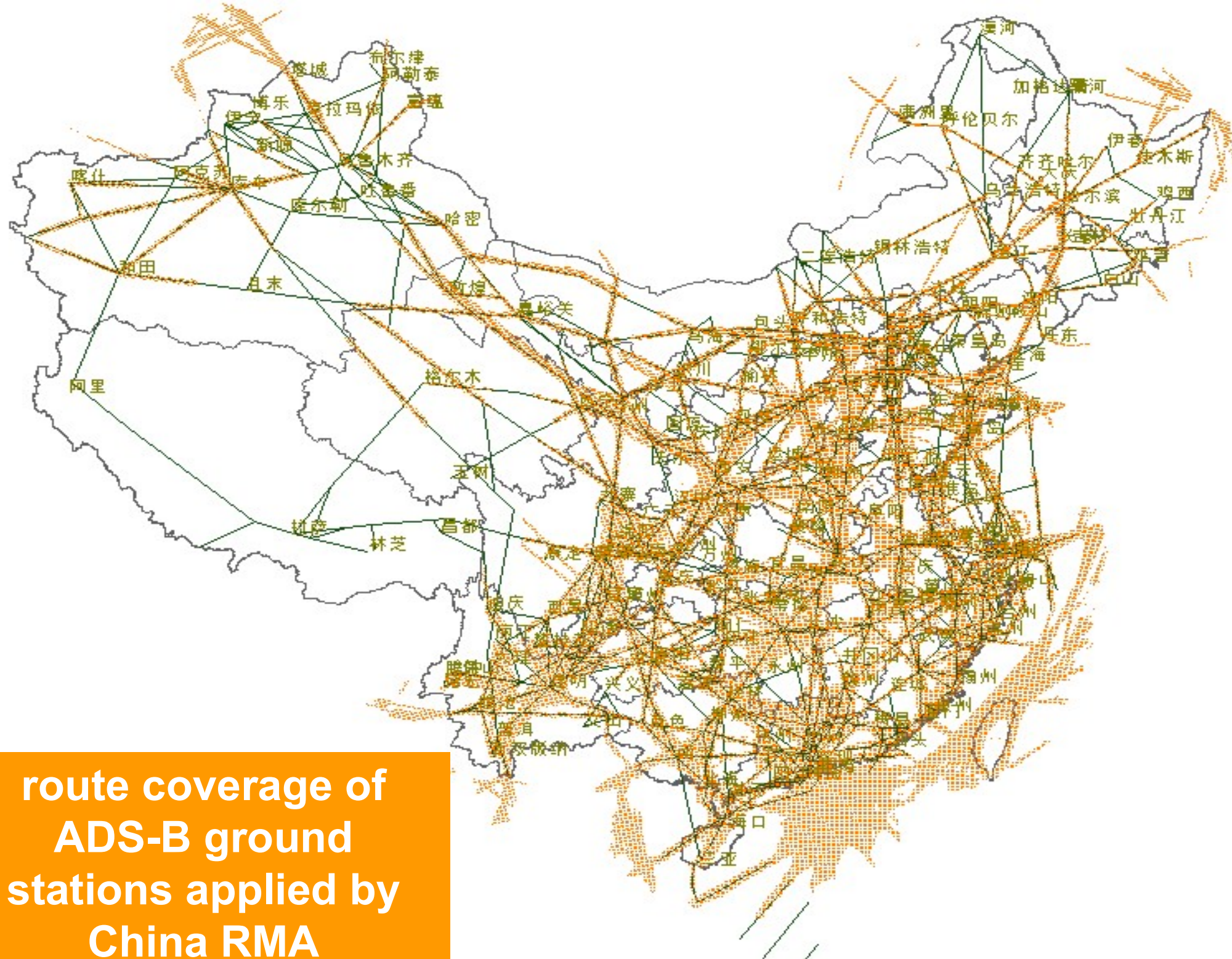
- The true shape of the Earth is not a regular sphere
- Two reference surfaces: HAE 、 MSL





Height Monitoring Systems



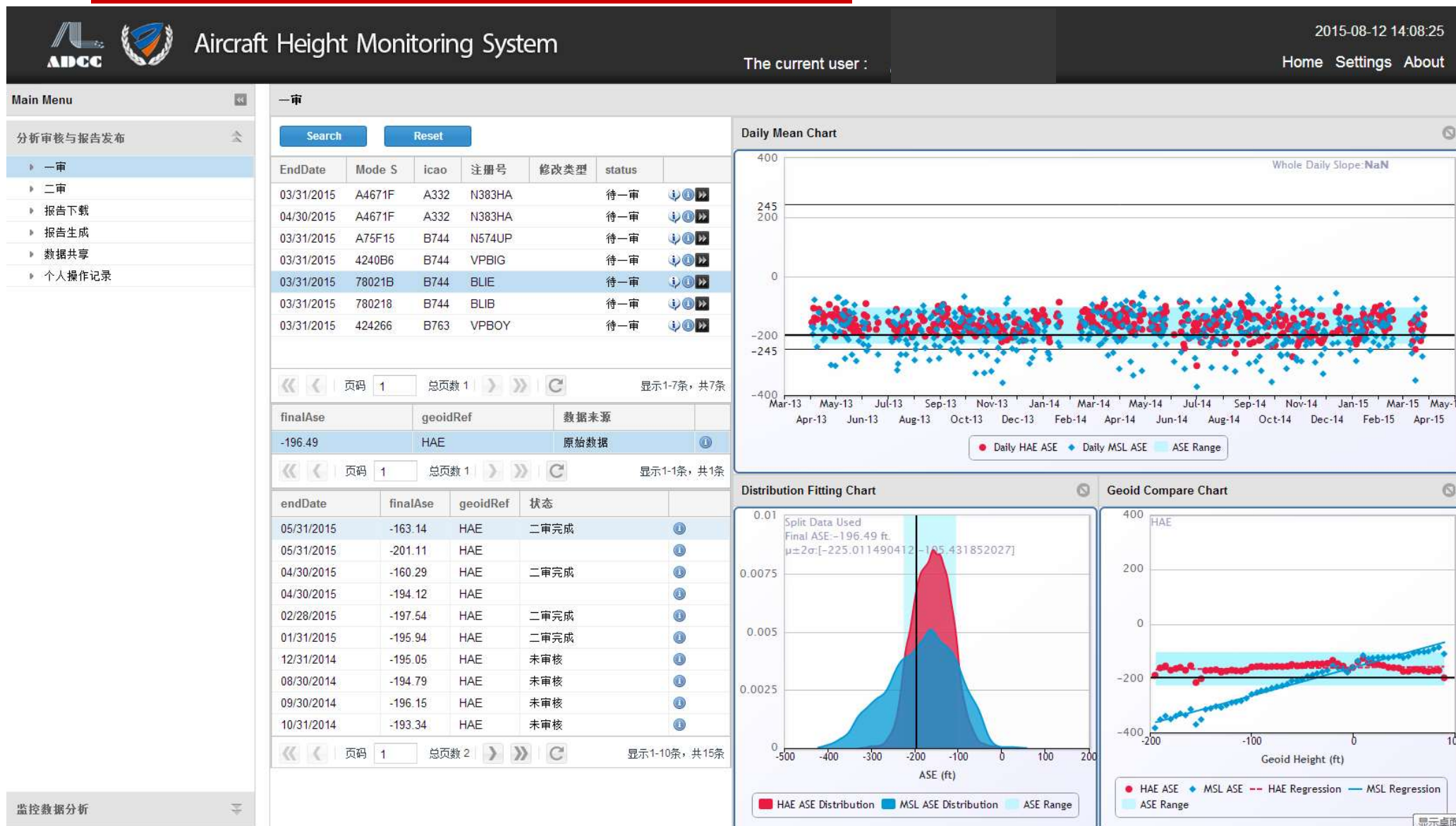


route coverage of
ADS-B ground
stations applied by
China RMA



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Height Monitoring Systems



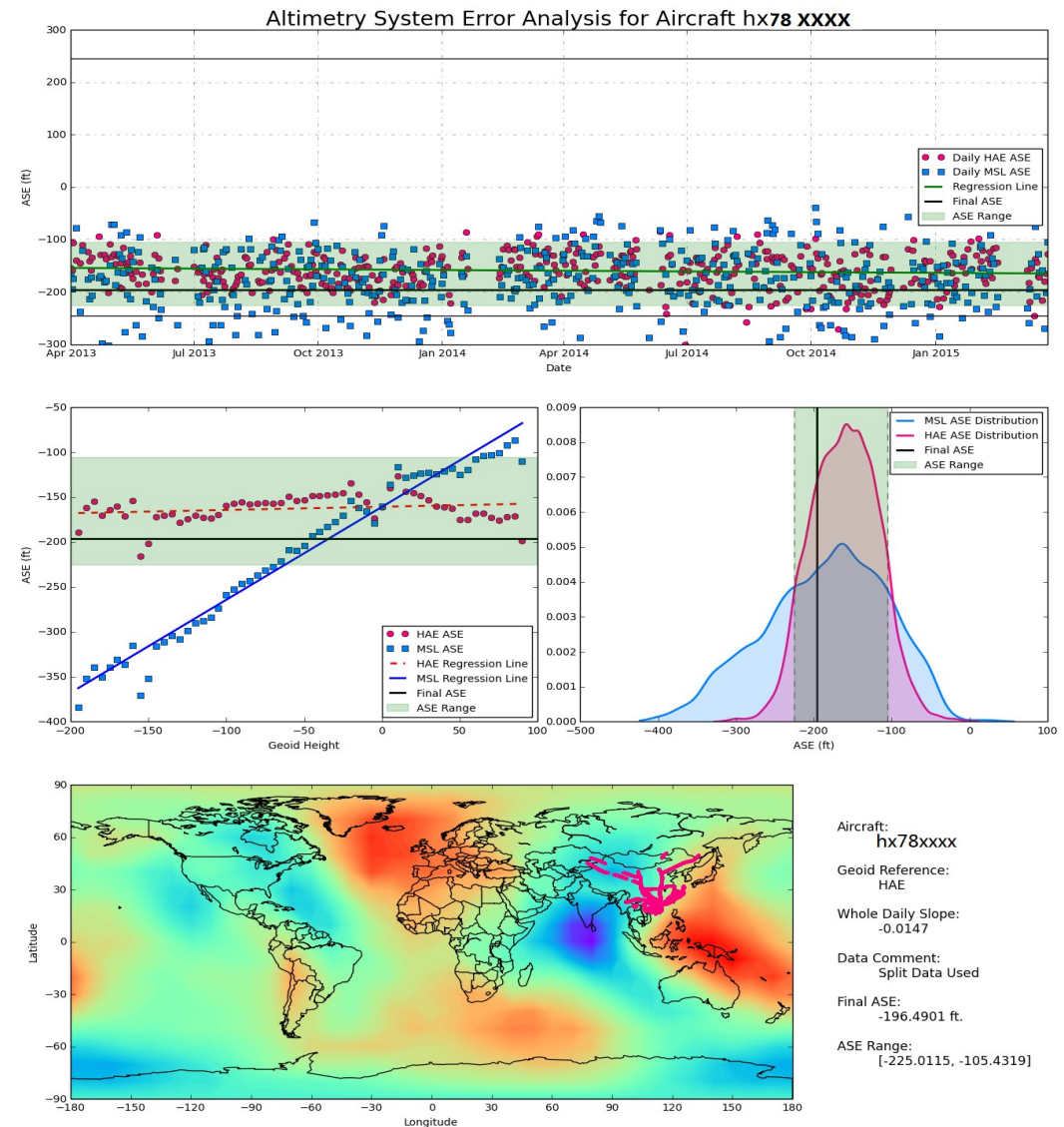


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Height Monitoring Systems

□ Analysis Plot

- ASE Daily mean chart
- ASE Distribution fitting chart
- ASE Geoid compare chart
- Flight Track





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Thank you

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