



# North American Approvals Registry and Monitoring Organization (NAARMO) Overview



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Federal Aviation  
Administration

# Overview

1

Global and international harmonization

----- ICAO Planning and Implementation Regional Groups (PIRGs)

2

Safety Objectives

3

Establishment of Regional Monitoring Agencies (RMAs)

4

RMA duties and responsibilities

5

RMA ASE-specific activities



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# ICAO Planning and Implementation Regional Groups (PIRGs)

The regional planning process is the principal engine of ICAO's planning and implementation work.



In order to enable the aviation community to collaboratively:

- ✓ Identify
- ✓ address and
- ✓ regularly reassess

safety and air navigation objectives at the global, regional and national levels, PIRGSs were established by ICAO for each ICAO region.



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# ICAO PIRG Objectives



## Global Guidance

- Provide global guidance and regional harmonization measures for proposals for implementation options.

## Regional Plans

- Support development of regional plans for air navigation systems including CNS/ATM systems

## Evaluate Air Navigation Systems

- Continuously study, monitor and evaluate the Air Navigation systems in light of ongoing change in air traffic characteristics and technological development.



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# ICAO PIRG Objectives



## Safety Standards

Maintain and, where possible, improve the agreed safety standards in all activities supporting the provision of air navigation services.

## Measure Safety Performance

Establish and measure safety performance against agreed safety standards at a regional level.

Safety Objectives of the RVSM monitoring program are detailed in ICAO Doc 9574



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# Safety Objectives of the RVSM Monitoring Program

The Manual on a 300 m (1000 ft.) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive (Doc 9574) states:

- ✓ Verification that the target level of safety will be met upon implementation of RVSM and will continue to be met thereafter
- ✓ Monitoring of the effectiveness of the altimetry system modifications which have been implemented to enable aircraft to meet the required height-keeping performance criteria
- ✓ Evaluation of the stability of altimetry system error (ASE)



Consequently, oversight bodies termed Regional Monitoring Agencies (RMAs), were established world-wide.



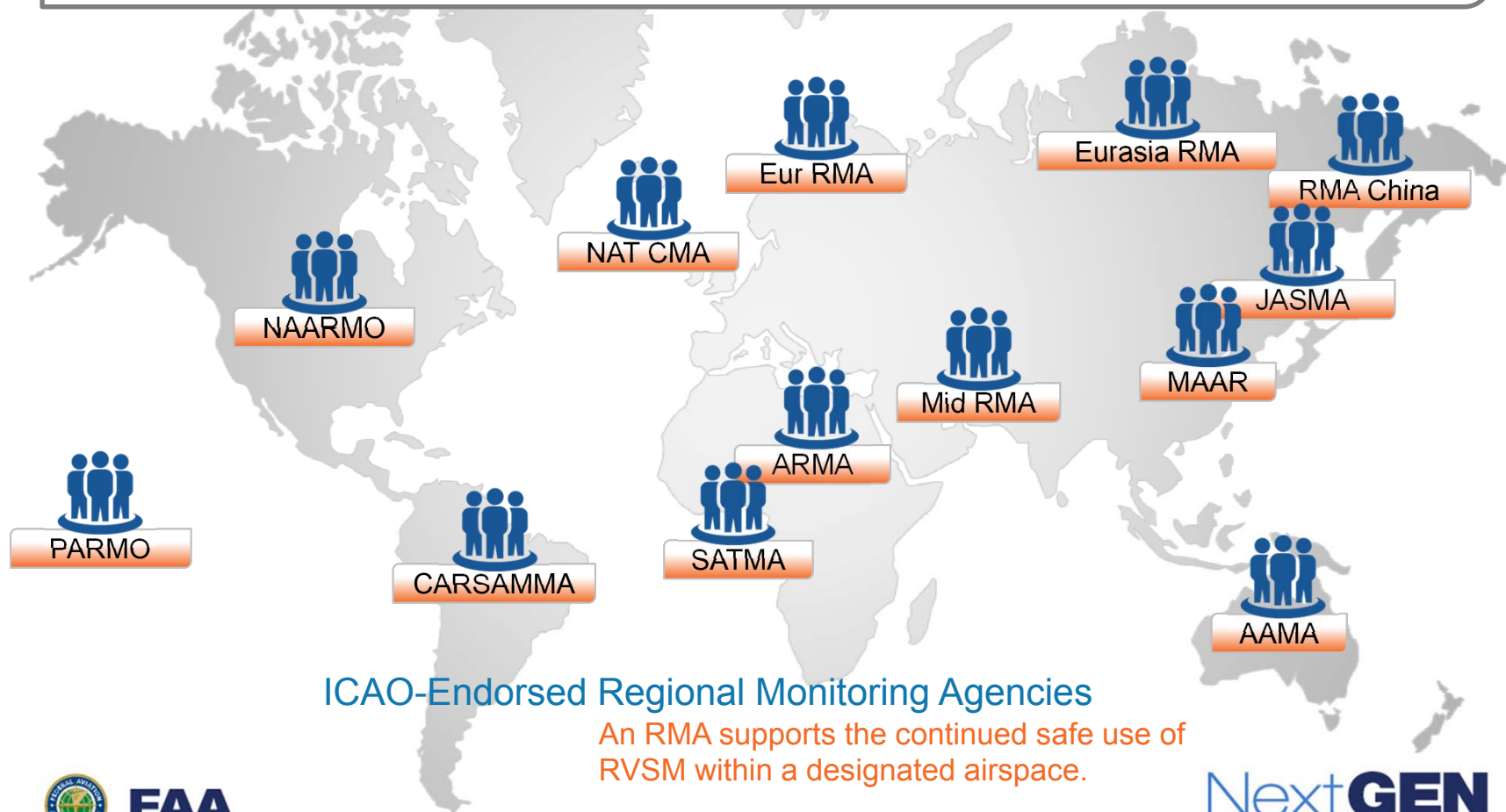
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Reference: ICAO Doc 9937, Forward

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# Regional Monitoring Agencies Worldwide

In all regions where RVSM has been implemented, regional monitoring agencies (**RMAs**) have been established by the appropriate planning and implementation regional groups (**PIRGs**) to satisfy the goals of the RVSM monitoring program.



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# Safety Goals/Target Level of Safety

- Determination of continued safe operations in RVSM airspace is measured against an ICAO-established safety goal – Target Level of Safety (TLS)
- One of the principal duties of an RMA is to conduct periodic safety assessments in order to determine whether the TLS continues to be met.
- A safety assessment consists of estimating the risk of collision associated with RVSM in two risk categories:
  - ✓ Operational risk
  - ✓ Technical risk



“Technical risk” is the term used to describe the risk of collision associated with aircraft height-keeping performance.



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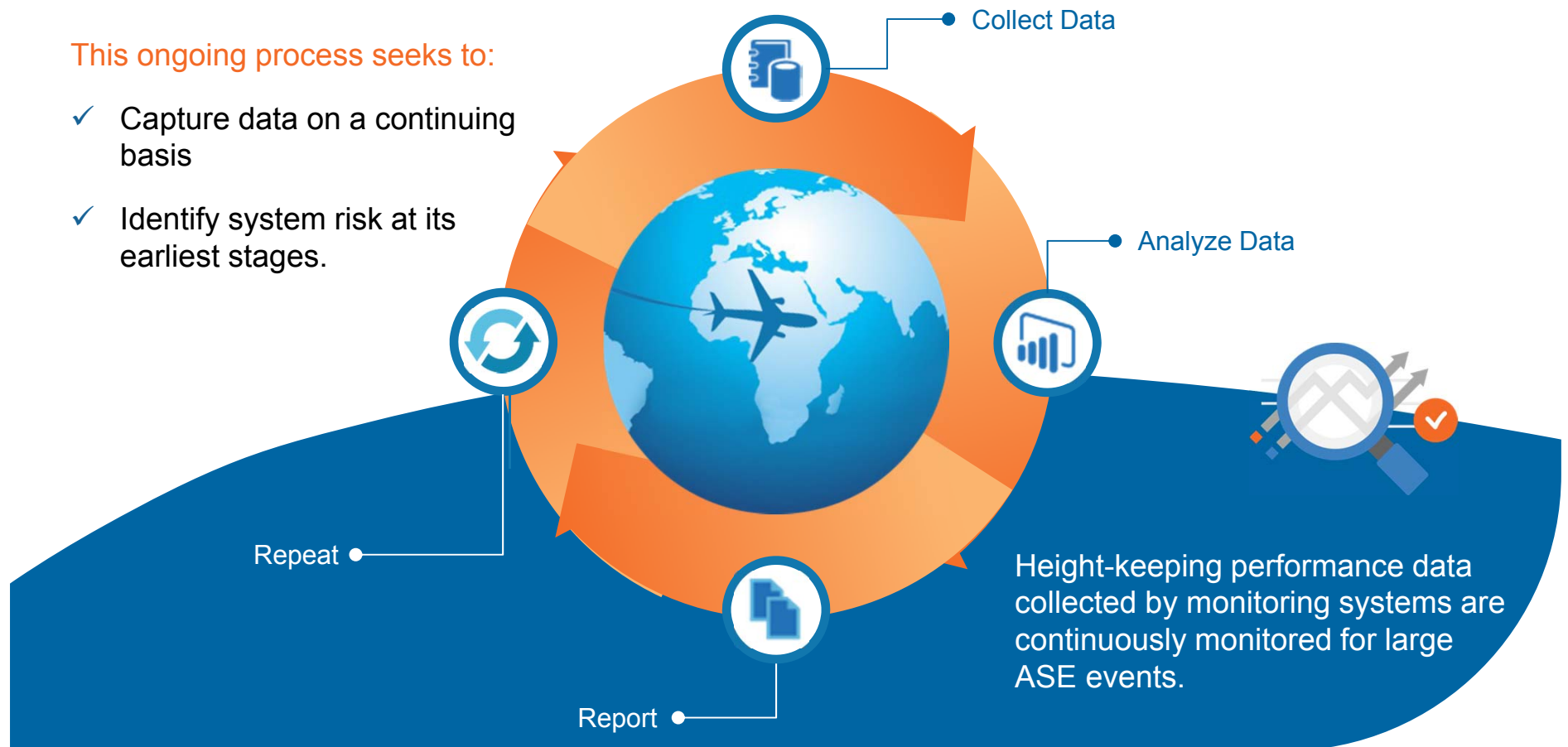


# Ongoing System Performance Monitoring

Determination of continued safe operations in RVSM airspace is satisfied by performing continuous monitoring of operations in the National Airspace System (NAS).

This ongoing process seeks to:

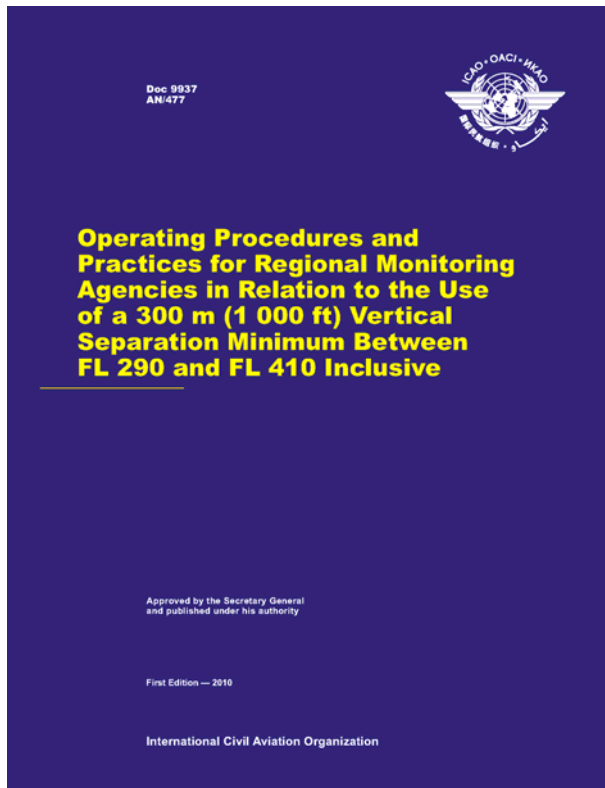
- ✓ Capture data on a continuing basis
- ✓ Identify system risk at its earliest stages.



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# ICAO RMA Guidance



In order to achieve a standardized approach to the way in which RMAs carry out their functions and the associated detailed duties and responsibilities of Doc 9574, ICAO guidance on RMA operating procedures is included in Doc 9937



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Reference: ICAO Doc 9937, paragraph 1.1,

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# RMA Duties and Responsibilities

1. Establish and maintain a database of aircraft approved by the respective State authorities for operations within RVSM airspace in that region
2. Receive reports of height deviations of aircraft observed to be non-compliant, based on the following criteria:
  - a) TVE  $\geq$  90 m (300 ft.)
  - b) ASE  $\geq$  75 m (245 ft.)
  - c) AAD  $\geq$  90 m (300 ft.)
3. Take the necessary action with the relevant State and operator to:
  - a) Determine the likely cause of the height deviation
  - b) Verify the approval status of the relevant operator
4. Recommend, wherever possible, remedial action



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Reference: ICAO Doc 9937, Appendix A

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## RMA Duties and Responsibilities (cont.)

5. Analyze data to detect height deviation trends
6. Undertake such data collections as are required by the PIRG to:
  - a) investigate height-keeping performance of the aircraft in the core of the distribution;
  - b) establish or add to a database on the height-keeping performance of:
    - the aircraft population
    - aircraft types or categories
    - individual airframes



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*Reference: ICAO Doc 9937, Appendix A*



## RMA Duties and Responsibilities (cont.)

7. Monitor the level of risk as a consequence of operational errors and in-flight contingencies as follows:
  - a) Establish a mechanism for collation and analysis of all reports of height deviations of 90 m (300 ft) or more resulting from the above errors/actions
  - b) Determine, wherever possible, the root cause of each deviation together with its size and duration
  - c) Calculate the frequency of occurrence
  - d) Assess the overall risk (technical combined with operational and in-flight contingencies) in the system against the overall safety objectives
  - e) Initiate remedial action as required



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*Reference: ICAO Doc 9937, Appendix A*

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## RMA Duties and Responsibilities (cont.)

8. Initiate checks of the “approval status” of aircraft operating in the relevant RVSM airspace, identify non-approved operators and aircraft using RVSM airspace and notify the appropriate State of Registry/State of the Operator accordingly;
9. Circulate regular reports on all height-keeping deviations, together with such graphs and tables necessary to relate the estimated system risk to the TLS
10. Submit annual reports to the PIRG.



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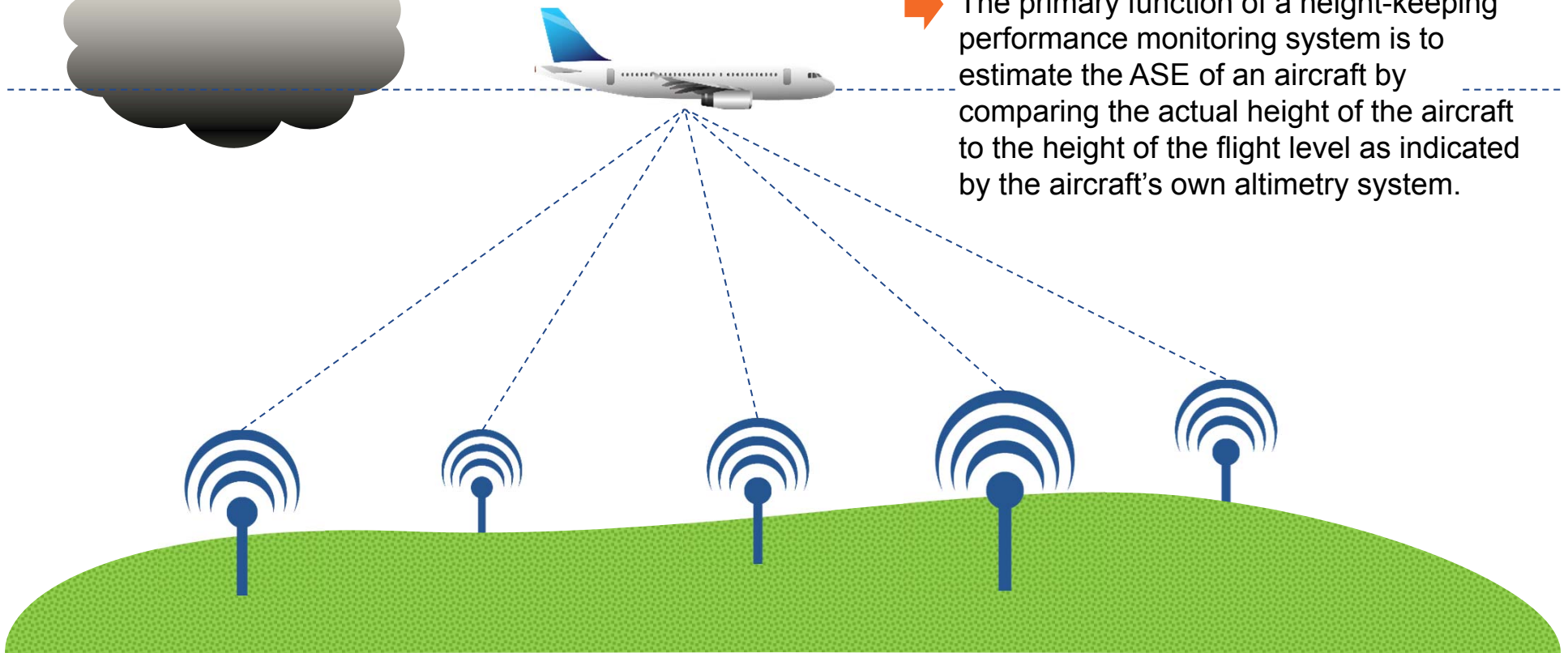
*Reference: ICAO Doc 9937, Appendix A*



# Height-Keeping Performance Monitoring Program

An RMA should design a height-keeping performance monitoring program to provide ongoing summary information of ASE performance by aircraft-type group so that adverse trends can be identified quickly.

➔ The primary function of a height-keeping performance monitoring system is to estimate the ASE of an aircraft by comparing the actual height of the aircraft to the height of the flight level as indicated by the aircraft's own altimetry system.



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Reference: ICAO Doc 9937, paragraph 2.5.3; Appendix E, paragraph 1.1

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# RVSM Height Monitoring Program

- The principal objectives of an RVSM monitoring program are to provide:
  - a) evidence of the effectiveness of the RVSM MASPS, and altimetry system modifications made in order to comply with the MASPS, in achieving the desired height-keeping performance;
  - b) confidence that the technical TLS is always met; and
  - c) evidence of Altimetry System Error (ASE) stability
- Processes – ASE, Meteorological (MET) & Quality Control (QC)
  - ✦ ASE is determined by comparing the identified true height of the aircraft and the true height of the barometric pressure surface associated with the altimetry measurement. Each available monitoring method provides the aircraft position.
  - ✦ MET & QC: There are software tools used to create the barometric pressure surfaces using the data from the National Weather Service which are then matched to the location of the aircraft to calculate ASE. Also, there are QC processes established to verify & confirm the data sources used for the ASE calculation & also processes in place to check for large ASE values.



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Reference: ICAO Doc 9937, paragraph 2.2.4

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# RVSM Height Monitoring

- All operators of aircraft approved to fly with a 1,000 ft vertical separation in RVSM airspace are required to participate in the global RVSM height monitoring program.
- The number of aircraft that require monitoring depends on both the size of an operator's fleet, and the variety of aircraft types operated.
- Monitoring aircraft height-keeping performance consists of:
  - ✦ collection of necessary data using specialized systems
  - ✦ estimation of relevant performance parameters and;
  - ✦ comparison of these parameter estimates to corresponding RVSM requirements, on both an individual-aircraft and a system-wide basis.

# Establishment of Long-Term Monitoring Requirements

- ICAO Separation and Airspace Safety Panel (SASP) identified that height-keeping performance monitoring results for RVSM approved aircraft had, in some cases, demonstrated long-term adverse trends in altimetry system error (ASE) stability.
- The likely results of this trend, if not reversed, would be aircraft becoming non-compliant with RVSM requirements.
- Accordingly, to ensure that adverse trends in ASE stability were detected, it was recognized that globally applicable RVSM long-term height monitoring requirements would be necessary.
- As a result of proposals made by the SASP, during 2007 the ICAO Air Navigation Commission (ANC) agreed to amendments to Annex 6 – Operation of Aircraft.



# RVSM Height Monitoring Requirements

- 7.2.6 The State of the Operator, in consultation with the State of Registry if appropriate, shall ensure that, in respect of those aeroplanes mentioned in 7.2.4 , adequate provisions exist for:
  - ✦ receiving the reports of height-keeping performance issued by the monitoring agencies established in accordance with Annex 11, 3.3.4.1; and
  - ✦ taking immediate corrective action for individual aircraft, or aircraft type groups, identified in such reports as not complying with the height-keeping requirements for operation in airspace where RVSM is applied.
- 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

**Performance And Minimum Monitoring Requirements For Transport Category Operators Are Outlined In Annex 6 Part I**



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*Reference: Annex 6, Part 1, paragraphs 7.2.6, 7.2.7*



# RVSM Height Monitoring Requirements

- 2.5.2.7 The State of Registry that has issued an RVSM approval to an owner/operator shall establish a requirement which ensures that a minimum of two aeroplanes of each aircraft type grouping of the owner/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 owner/operator aircraft type grouping consists of a single aeroplane, monitoring of that aeroplane shall be accomplished within the specified period.



**Minimum Monitoring Requirements for IGA Operators are Outlined in Annex 6 Part II**



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Reference: Annex 6, Part II, paragraph 2.5.2.7

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# Monitoring Methods

## Monitoring systems available in North America:



**GPS-based Monitoring Unit (GMU)** – a portable device brought on board and operated by trained technicians. This method uses GPS data to collect the aircraft's position that is then used in the ASE process.



**Aircraft Geometric Height Measuring Element (AGHME)** – with this method, the true altitude is currently measured by the ground-based AGHME multilateration technique systems operated by the FAA.



**Automatic Dependent Surveillance-Broadcast (ADS-B) Height Monitoring System (AHMS)** – provides a source of aircraft position data for use in the ASE calculations.



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# Monitoring Methods by RMA

RMA		GMU	HMU	ADS-B
AAMA	Australian Airspace Monitoring Agency	✓		✓
ARMA	African and Indian Ocean (AFI) Regional Monitoring Agency	✓		
CARSAMMA	Caribbean and South American Monitoring Agency	✓		
China RMA	China Regional Monitoring Agency	✓		✓
EurAsia RMA	Regional Monitoring Agency Eurasia	✓		
Eur RMA	European Regional Monitoring Agency	✓	✓	
JASMA	Japan Airspace Safety Monitoring Agency	✓	✓	
MAAR	Monitoring Agency for Asia Region	✓		✓
Mid RMA	Middle East Regional Monitoring Agency	✓		
NAARMO	North American Approvals Registry and Monitoring Org	✓	✓	✓
NAT CMA	North Atlantic Central Monitoring Agency	✓	✓	
PARMO	Pacific Approvals Registry and Monitoring Organization	✓		✓
SATMA	South Atlantic Monitoring Agency	✓		



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# Review/Summary of ASE Performance

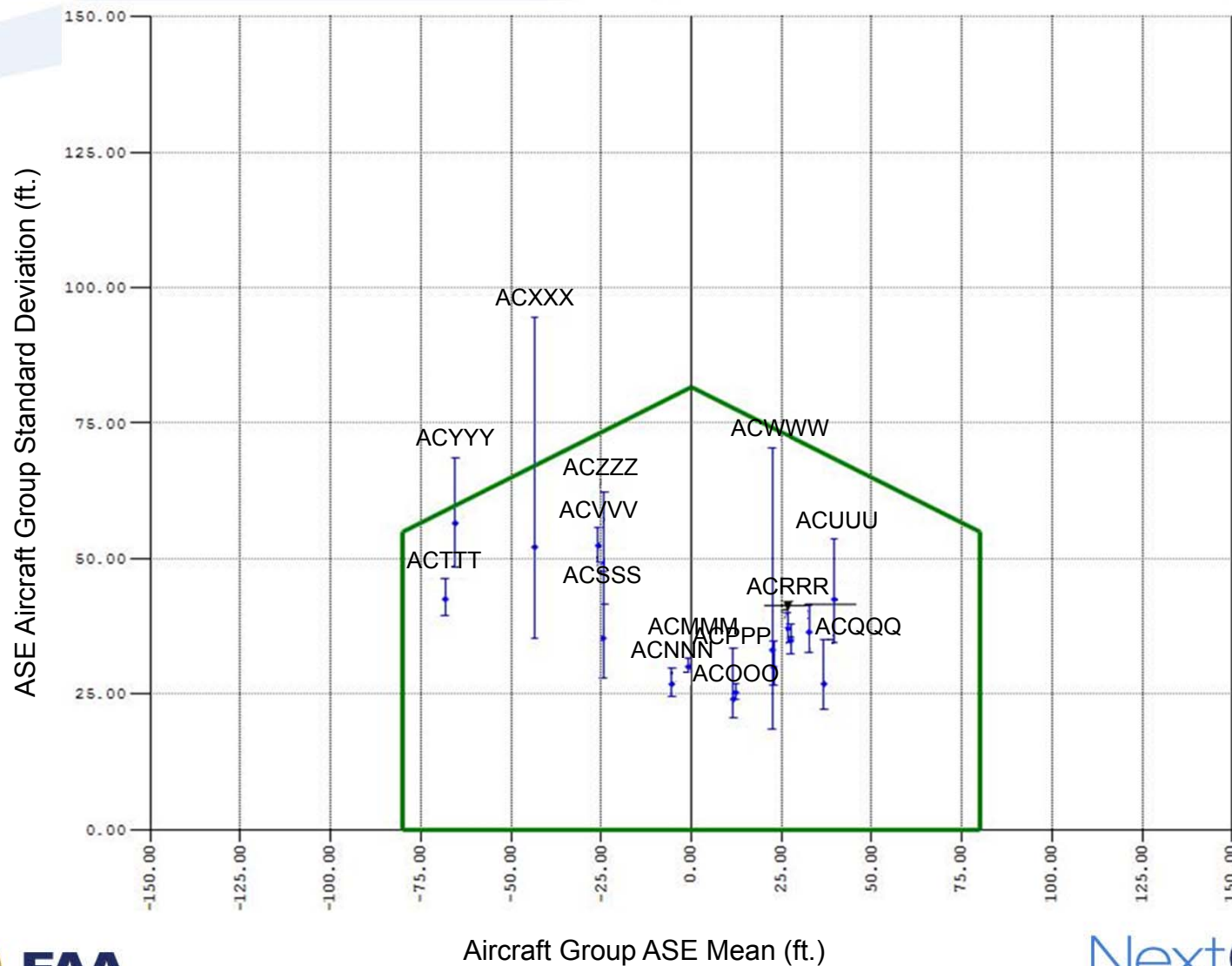
- Continued safe RVSM operations require a high level of accuracy from altimetry systems
- RVSM monitoring programs world-wide have collected and analyzed height-keeping performance data to determine the stability of Altimetry System Error (ASE) of airframes operating within the RVSM stratum
- Analysis results revealed that ASE can vary
  - ✦ Within a population of the same aircraft type at any point in time
  - ✦ And by individual aircraft over any period of time
- Data analysis results clearly identified the technical problems in altimetry systems and long-term adverse trends in ASE stability
- The need to establish an ASE independent monitoring program and develop a reporting mechanism was identified



## Review/Summary of ASE Performance (cont.)

- An RMA employing a height-keeping performance monitoring system producing substantial estimates of aircraft ASE should keep tabulations of ASE by aircraft-type groups, as identified in the MMR.
- For each group, the magnitude of mean ASE and mean ASE + 3\*SD should be calculated and compared to the group performance limits:
  - ✦ 25 m (80 ft) (Mean ASE)
  - ✦ 75 m (245 ft) (Mean ASE + 3\*SD)
- Groups exceeding the performance requirements must be investigated and reported annually, or more frequently as required, to the body which authorized the establishment of the RMA.

# Aircraft Group ASE Performance



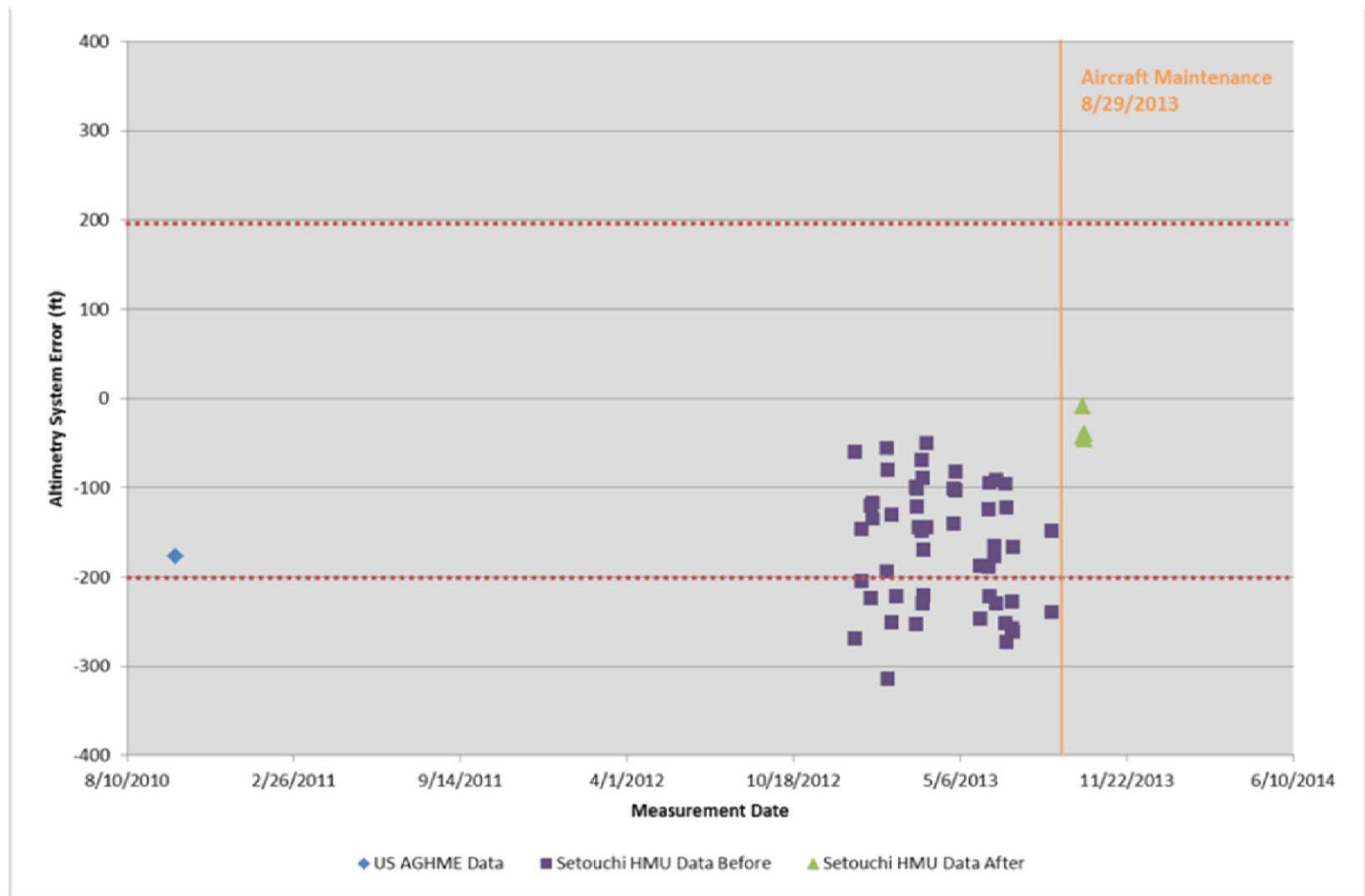
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Aircraft Group ASE Mean (ft.)



# Case Study of Airframe ASE Performance

- Aircraft exceeding performance requirements must also be investigated.
- In this case, coordination between RMAs confirmed results.
- Operator was informed by NAARMO (ASER).
- Operator performed maintenance and re-monitored successfully.



# Remedial Actions

- Remedial actions are those measures taken to remove causes of systematic problems associated with factors affecting safe use of RVSM.
- RMAs must be proactive in the identification, reporting and resolution of all causes of risk.
- Remedial actions may be necessary to remove the causes of problems such as the following:
  - a) Failure of an aircraft-type group to comply with group ASE requirements
  - b) Failure of individual airframes to meet ASE compliance requirements



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*Reference: ICAO Doc 9937, paragraph 2.5.1*

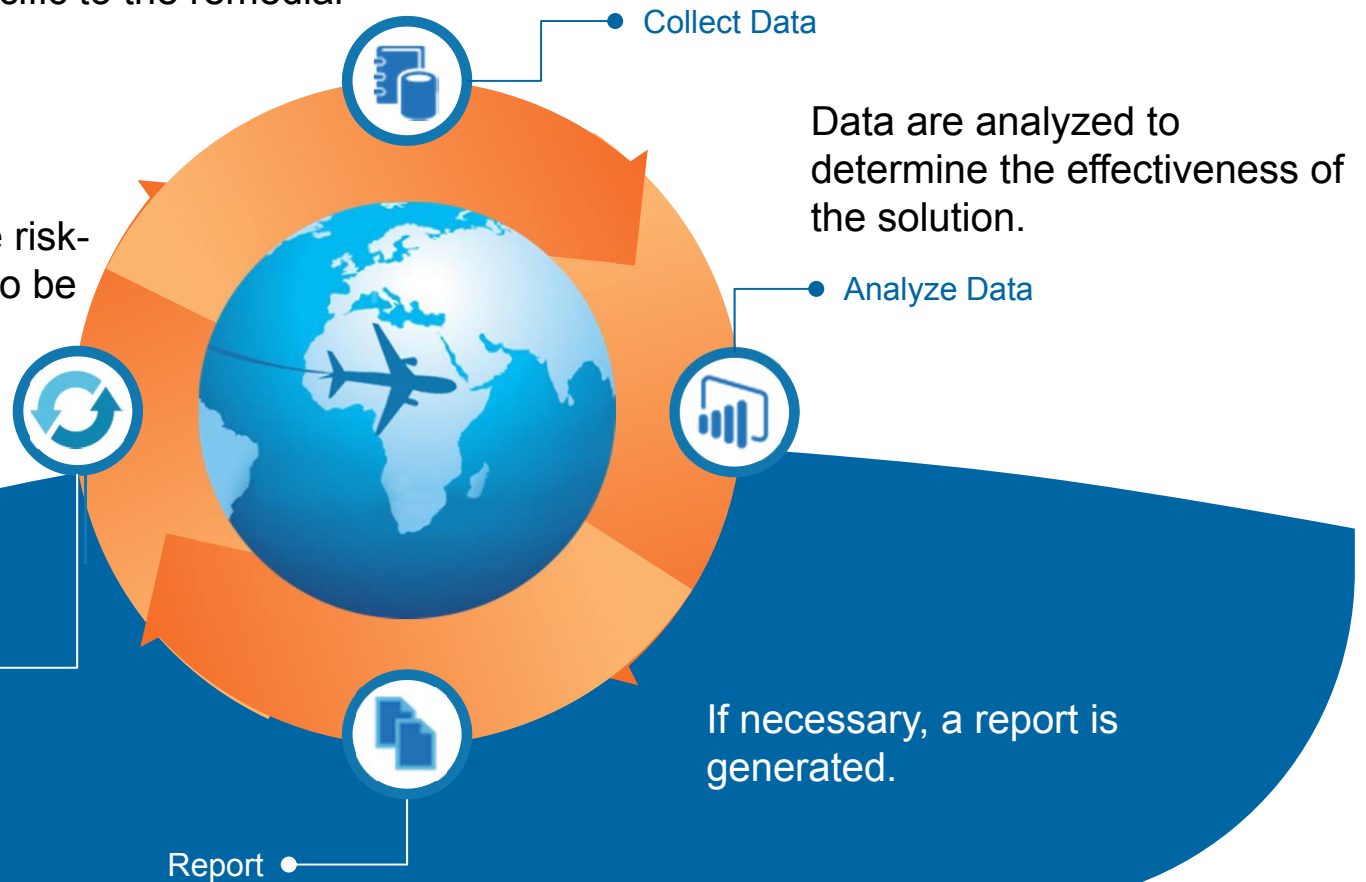


# Ongoing System Performance Monitoring

## Remedial Actions

During the ongoing data collection process, operational data specific to the remedial action are captured.

The process repeats until the risk-bearing issue is determined to be remediated and related operations are safe.



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