



**GUIDANCE MATERIAL FOR THE CONTINUED SAFETY MONITORING
OF THE AFRICA INDIAN OCEAN RVSM AIRSPACE**

Version 1.0

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FOREWORD

Guidance Material for the Continued Safety Monitoring of the AFI RVSM Airspace will be published by the ESAF Office of ICAO, on behalf of the Africa Indian Ocean Planning and Implementation Regional Group (APIRG).

The purpose of this document is to describe the post-implementation safety monitoring activities for RVSM airspace, including the respective roles and responsibilities of States and Regional Monitoring Agencies (RMAs). It also signifies the importance of a collaborative approach to ensure the continued safe operation of RVSM in the Africa Indian Ocean Region.

The Guidance material will be updated from time to time by the Africa Indian Ocean Regional Monitoring Agency (ARMA) and amendments will be issued accordingly.

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AUTHORITY	NAME	CONTACT DETAILS	SIGNATURE	DATE
ICAO Regional Office				
Head: ARMA	Nonjabulo Gumede	Afirma@atns.co.za +2763 691 2295		
Director of CAA/ANSP				
National Program Manager				

TABLE OF CONTENTS

LIST OF DEFINITIONS.....	i
LIST OF ABBREVIATIONS.....	iii
1. INTRODUCTION.....	1
Background.....	1
Scope and Purpose of the Document.....	2
2. RVSM REGULATORY REQUIREMENTS AND MONITORING ACTIVITIES.....	3
ICAO Annex 6.....	3
ICAO Doc. 7030.....	5
Regional Monitoring Agencies.....	6
Monitoring Compliance with Requirements.....	7
<i>RVSM Approvals.....</i>	<i>8</i>
<i>Aircraft Technical Height Monitoring Programme.....</i>	<i>8</i>
<i>Operational Risk Events.....</i>	<i>9</i>
<i>RMA/State Interfaces.....</i>	<i>9</i>
3. RVSM APPROVAL PROCESSES.....	10
RVSM airworthiness approval.....	11
Validity of an RVSM operational approval.....	12
RVSM approvals - RMA.....	13
RVSM approvals - States.....	14
RVSM approvals – Flight planning.....	15
RMA action of non-approved and non-compliant aircraft.....	16
4. RMA/STATE COORDINATION.....	17
RMA contacts.....	17
State contacts.....	17
Inappropriate State Actions.....	18
5. TECHNICAL HEIGHT KEEPING PERFORMANCE AND MONITORING.....	19
Height Monitoring Systems.....	19
Operator Long Term Height Monitoring Programme.....	20
ASE Performance Investigations.....	21
6. ALTITUDE DEVIATION AND OTHER OPERATIONAL REPORTS.....	23
Description of Operational Events.....	23
Reporting of Operational Events.....	24

Appendix A – TERMS OF REFERENCE OF AFRICA INDIAN OCEAN MONITORING AGENCIES	A - 1
Appendix B – APIRG CONCLUSIONS AND DECISIONS.....	B - 1
Appendix C – LHD/LLE/LLD TAXONOMY	C - 1

LIST OF DEFINITIONS

The following definitions are provided in order to clarify certain specialised terms used in this document:

Accredited States

Those States within an RVSM region which are collectively responsible for coordination, through a single Regional Monitoring Agency, for the implementation of APIRG RVSM safety policy, decisions, exchange of RVSM approvals, large height deviations, long term height-keeping monitoring data and other RVSM related information.

Accredited RMA

An RMA, established by APIRG, to which a State is accredited for the coordination of RVSM related issues.

Altimetry System Error (ASE)

The difference between the altitude indicated by the altimeter display assuming a correct altimeter barometric setting and the pressure altitude corresponding to the undisturbed ambient pressure.

Assigned Altitude Deviation (AAD)

The difference between the transponder Mode C altitude and the assigned altitude/flight level.

Automatic Altitude Control System

Any system which is designed to automatically control the aircraft to a referenced pressure altitude.

General Air Traffic (GAT)

Flights conducted in accordance with the rules and provisions of ICAO.

Collision Risk

The expected number of mid-air aircraft accidents in a prescribed volume of airspace for a specific number of flight hours due to loss of planned separation.
(Note - one collision is considered to produce two accidents.)

Height-Keeping Capability

Aircraft height-keeping performance which can be expected under nominal environmental operating conditions with proper aircraft operating practices and maintenance.

Height-Keeping Performance

The observed performance of an aircraft with respect to adherence to cleared flight level.

Hexadecimal Number Format

A representation of a 4 bit binary number (0-15 in decimal) by use of numbers 0 to 9 and letters A to F

Large Height Deviation

A vertical deviation of 300 ft or more from an ATC assigned or coordinated altitude. The deviation may be the result of human error, equipment malfunction or environmental factors such as turbulence, and should be reported in accordance with the LHD types in Appendix C.

Operational Air Traffic (OAT)

Flights which do not comply with the provisions stated for GAT and which rules and procedures have been specified by appropriate authorities.

Reduced Vertical Separation Minimum (RVSM)

A vertical separation minimum of 300 m (1 000 ft) which is applied between FL 290 and FL 410 inclusive, on the basis of regional air navigation agreements and in accordance with conditions specified therein.

RVSM Approval

The approval that is issued by the appropriate authority of the State in which the Operator is based or the State in which the aircraft is registered

State Aircraft

Aircraft used in Military, Customs, and Police services shall be deemed to be State Aircraft (Reference - ICAO Convention on International Civil Aviation, Article 3 (b)).

Static Source Error

The difference between the pressure sensed by the static system at the static port and the undisturbed ambient pressure.

Static Source Error Correction (SSEC)

A correction which may be applied to compensate for the static source error associated with an aircraft.

Target Level of Safety (TLS)

A generic term representing the level of risk which is considered acceptable in particular circumstances.

Vertical Separation

Vertical separation is the spacing provided between aircraft in the vertical plane to avoid collision.

LIST OF ABBREVIATIONS

The acronyms listed hereunder have been chosen from those which are specifically related to activities of the APIRG and/or are most frequently found in this report in order to assist in its reading.

AAD	Assigned Altitude Deviation
AFI	Africa Indian Ocean
ADS-B	Automatic Dependent Surveillance - Broadcast
AHMS	ADS-B Height Monitoring System
AMC	Acceptable Means of Compliance
AOC	Air Operator's Certificate
APIRG	Africa Indian Ocean Planning and Implementation Regional Group
ASE	Altimetry System Error
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
CFL	Cleared Flight Level
CRM	Collision Risk Model
FIR	Flight Information Region
FL	Flight Level
GAT	General Air Traffic
GMU	GPS Monitoring Unit
GPS	Global Positioning System
HMU	Height Monitoring Unit
ICAO	International Civil Aviation Organisation
IGA	International General Aviation
LHD	Large Height Deviation
LTHM	Long Term Height Monitoring requirements
MASPS	Minimum Aircraft System Performance Specification
MEL	Minimum Equipment List
NSA	National Supervisory Authorities
OAT	Operational Air Traffic
PANS	Procedures for Air Navigation Services
RMA	Regional Monitoring Agency
RPG	Regional Planning Group
RVSM	Reduced Vertical Separation Minimum of 300 m (1000 ft) between FL 290 and FL 410 inclusive
SSE	
SSEC	Static Source Error
SSR	Static Source Error Correction
	Secondary Surveillance Radar

STC	Supplementary Type Certificate
TC	Type Certificate
TCAS	Traffic Collision and Avoidance System
TLS	Target Level of Safety
TVE	Total Vertical Error
VSM	Vertical Separation Minimum

1. INTRODUCTION

Background

1.1 The implementation of a Reduced Vertical Separation Minimum between FL 290 and FL 410 in the Africa Indian Ocean Air Navigation Region provided the benefits of additional en-route capacity and improved fuel efficiency for aircraft operators. Such a major transformation of the separation minimum required extensive safety analysis of the inherent increase in the risk of mid-air collision, which resulted in the definition of more stringent aircraft altitude keeping performance requirements. A monitoring programme was also initiated to ensure that both the technical and operational safety issues of the new separation standard were appropriately identified and addressed prior to implementation.

1.2 The new aircraft performance requirements were incorporated into a number of global standards and Acceptable Means of Compliance (AMC). These are generically termed Minimum Aircraft System Performance Specifications (MASPS). The MASPS include the minimum build standard and equipment configuration of an aircraft, the accuracy of the altimetry system over the full operational flight envelope and the continued airworthiness procedures necessary to ensure that the performance is maintained. Operators which demonstrated both technical compliance and the application of appropriate operational procedures obtained an approval to operate within RVSM airspace with 1,000 ft. vertical separation.

1.3 The pre-implementation safety programme required monitoring of aircraft technical height keeping performance, verification of aircraft/operator RVSM approval status and the undertaking of a collision risk assessment to ensure that an internationally agreed Target Level of Safety (TLS) was satisfied.

1.4 Analysis of the data provided by the pre-implementation monitoring programme indicated that although the risk level was acceptable, some of the initial assumptions regarding approval requirements and the accuracy of aircraft height keeping performance were not correct. Specifically, it was assumed that only approved aircraft would operate within the airspace and that aircraft altimetry system performance would remain stable over time.

1.5 In 2002, ICAO took the decision that in all regions in which RVSM had been implemented, it would be necessary for the Regional Planning Groups (RPG) to initiate programmes for the continuous monitoring of aircraft height keeping performance to ensure that risk levels remained below the TLS. In addition these programmes would include monitoring the compliance of operator/aircraft approval requirements.

1.6 In the Africa Indian Ocean Region, the Regional Airspace Safety Monitoring Advisory Group (RASG) was established by the Africa Indian Ocean Planning and Implementation Regional Group (APIRG) to achieve a regional approach for coordination and harmonization of airspace safety monitoring activities, and where necessary provide assistance to States to acquit their responsibilities.

1.7 To support the work of the ARMA, five regional monitoring agencies (RMAs) have been established and endorsed by APIRG. The RMAs conduct airspace monitoring and safety oversight activities on behalf of States accredited to their respective regions in accordance with the procedures and processes detailed in 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*.

1.8 This responsibility includes monitoring operators/aircraft with regards to height keeping performance and approval status, and long term fleet monitoring requirements. The responsibility of the RMA is limited to monitoring operator compliance with the various technical and operational requirements and reporting any non-compliance or safety issue to the State exercising operational authority over that operator. It remains the responsibility of individual States to ensure that any appropriate remedial action is taken.

1.9 Common Terms of Reference (ToR) for all RMAs are approved by RMACG and are reproduced in Appendix A of this document.

Scope and Purpose of the Document

1.10 The scope of this document is limited to those activities specifically associated with the post implementation safety monitoring responsibilities conducted by an RMA on behalf of, and supported by, accredited States. It is not intended in this document to provide a comprehensive description of operational procedures and practices which are defined elsewhere, although reference is made to these when appropriate.

1.11 The purpose of this document is to describe the post-implementation safety monitoring activities for RVSM airspace, the respective roles and responsibilities of RMAs and States and the importance of a collaborative approach to ensure the continued safe operation of RVSM in the Africa Indian Ocean Region

1.12 The document describes the regional framework established by ARMA and interaction between stakeholders which is required to support the safe operation of RVSM and demonstrate compliance with regulatory requirements.

1.13 The specific purpose of this guidance material is therefore to:

- a) Encapsulate the regulatory requirements contained in Annex 6 and 11 to the Convention on International Civil Aviation and to describe a practical safety monitoring framework in order to meet the particular demands of the Africa Indian Ocean RVSM airspace;
- b) describe the principle roles and interfaces of the APIRG, accredited member State and the RMA to provide an effective framework for all safety monitoring and oversight activities;
- c) describe the data exchange and coordination requirements between the RMA and State National Supervisory Authorities as well as recommended working practices; and
- d) provide recommendations for appropriate action in the event of operator non-compliance with RVSM approval or performance requirements.

1.14 To facilitate comprehension this document often refers to the operations and role of the AFI RMA in the definite singular article (The RMA).

2. RVSM REGULATORY REQUIREMENTS AND MONITORING ACTIVITIES

2.1 There are a number of documents which relate to requirements, guidance and best practices for the safe continuous operation of RVSM. Some of these documents are in effect regulatory requirements which govern all contracting States to the Convention on International Civil Aviation (unless States have notified ICAO of any differences). These are the Annexes to the Convention on International Civil Aviation and are defined as International Standards and Recommended Practices (SARPs). Other documents relate to procedures, the application of which is governed by the Annexes. Finally there is guidance material including the Acceptable Means of Compliance related to aircraft MASPS, the application of RVSM and the operating procedures for an RMA.

2.2 The major documents which impact the application of RVSM and the responsibilities related to technical aircraft performance, safety oversight and compliance monitoring are described below in **Table 1**.

Document	Description	Type
ICAO Annex 11	High level requirements for the establishment of regional monitoring agencies in all regions in which RVSM has been implemented	SARPs
ICAO Annex 6 (Part 1 and 2)	The operation of Aircraft	SARPs
ICAO Annex 8	Airworthiness of Aircraft	SARPs
ICAO Doc. 4444	Procedures for Air Navigation Services – Air Traffic Management	Procedures (governed by ICAO Annexes)
ICAO Doc. 7030	Regional Supplementary Procedures	Regional Procedures (governed by ICAO Annexes)
ICAO Doc. 9574	Implementation of a Reduced Vertical Separation Minimum	ICAO Guidance material
ICAO Doc. 9937	Operating procedures for Regional Monitoring Agencies	ICAO Guidance material

Table 1: Documents Related to Regulatory Requirements and Safety Oversight Activities within RVSM Airspace

2.3 Of the documents listed above in **Table 1**, ICAO Annex 6 and ICAO Doc. 7030 contain the most relevant information related the material contained in this document. The following sections expand on the specific RVSM requirements contained in these two documents.

2.4 Please note that the referencing paragraph numbers are omitted on purpose for maintainability of this document.

ICAO Annex 6

2.5 Annex 6 to the Convention on International Civil Aviation defines requirements for the operation of aircraft. Part 1 relates to commercial operators and part 2 to operators of IGA aircraft.

2.6 Prior to granting an RVSM approval a State is required to confirm that the aeroplane satisfies minimum equipment and height keeping performance requirements. The State must also be satisfied that the operator has instituted appropriate continued airworthiness and flight crew procedures and practices. Following the granting of an approval the State is responsible for ensuring that the aircraft continues to meet height keeping performance requirements, that all operators participate in regional or global monitoring programmes and that only approved aircraft operate within the airspace.

2.7 A summary of the responsibilities of individual State Authorities defined in ICAO Annex 6 are reproduced below in **Table 2**.

Annex 6 Part 1	Annex 6 Part 2
Aeroplane equipment requirements	
Aeroplane shall be approved by State of Operator	Aeroplane shall be approved by State of Registry
Aeroplane vertical navigation performance requirements	
Pre-approval aeroplane/operator requirements	
State (of Operator) responsibility to ensure provisions for receiving reports from accredited RMA and implementing measures to correct the performance of aircraft not compliant with height keeping requirements	State (of Registry) responsibility to ensure provisions for receiving reports from accredited RMA and implementing measures to correct the performance of aircraft not compliant with height keeping requirements
State of Operator that has issued an RVSM approval to an operator shall ensure that the operator complies with biennial fleet monitoring targets.	State of Registry that has issued an RVSM approval to an operator shall ensure that the operator complies with biennial fleet monitoring targets.
<p>All States that are responsible for airspace where RVSM has been implemented, or which have issued RVSM approvals shall establish provisions and procedures to ensure that appropriate action will be taken with operators of non-approved aircraft.</p> <p>(These provisions and procedures need to address both the situation where the aircraft is operating without approval in the airspace of the State and the situation where an operator for which the State has regulatory oversight responsibility is found to be operating without the required approval in the airspace of another State.)</p>	
The aeroplane shall be sufficiently provided with navigation equipment to ensure that, in the event of the failure of one item of equipment at any stage of the flight, the remaining equipment will enable the aeroplane to navigate in accordance with [aeroplane equipment requirements]	

Table 2: Summary of Requirements for the Approval and Operation of Aircraft in RVSM Airspace

2.8 States should ensure that appropriate processes and procedures are in place to take appropriate action with operators who fail to comply with the regulatory requirements, or operate aircraft which no longer comply with the conditions under which an RVSM approval was issued. Such action may include withdrawal of an RVSM approval on a temporary or permanent basis.

ICAO Doc. 7030

2.9 Regional requirements are contained in ICAO Regional Supplementary Procedures, ICAO Doc. 7030. The principle supplementary procedures related to RVSM are summarized below in **Table 3**.

Doc 7030 Supplementary Procedures Summary	
General	<ul style="list-style-type: none"> • Within the RVSM airspace, the vertical separation minimum shall be 300 m (1 000 ft). • Operators intending to conduct flights within the airspace where RVSM is applied shall require an RVSM approval either from the State of Registry or the State of the Operator. The State of Registry or the State of the Operator, as appropriate, should verify that the height-keeping performance capability of approved aircraft meets the requirements specified in Annex 6, Parts I and II. • Within the RVSM airspace, aircraft that have not received RVSM State approval may be cleared to operate in accordance with policy and procedures established by the State provided that 600 m (2 000 ft) vertical separation is applied. • ATC clearance into RVSM airspace shall not be issued to formation flights of civil aircraft. • If the receiving unit has not received a flight plan, the sending unit shall verbally inform the receiving unit whether or not the aircraft is RVSM-approved. • Monitoring of flight operations in the RVSM airspace shall be conducted to assess the continuing compliance of aircraft with the height-keeping performance requirements.
In-Flight Contingency	<p>An in-flight contingency affecting flight in RVSM airspace pertains to unforeseen circumstances that directly impact on the ability of one or more aircraft to operate in accordance with the vertical navigation performance requirements of RVSM airspace. Such in-flight contingencies can result from degradation of aircraft equipment associated with height-keeping or from turbulent atmospheric conditions.</p> <ul style="list-style-type: none"> • When a single aircraft is experiencing an in-flight contingency that impacts on RVSM operations, the associated coordination message(s) shall be supplemented verbally by a description of the cause of the contingency. • The pilot shall inform ATC as soon as possible of any circumstances where the vertical navigation performance requirements for RVSM airspace cannot be maintained. In such cases, the pilot shall obtain a revised ATC clearance prior to initiating any deviation from the cleared route and/or flight level, whenever possible. When a revised ATC clearance cannot be obtained prior to such a deviation, the pilot shall obtain a revised clearance as soon as possible thereafter. • When informed by the pilot of an RVSM-approved aircraft operating in RVSM airspace that the aircraft's equipment no longer meets the RVSM requirements, ATC shall consider the aircraft as non-RVSM-approved. • ATC shall take action immediately to provide a minimum vertical separation of 600 m (2 000 ft) or an appropriate horizontal separation from all other aircraft concerned that are operating in RVSM airspace. An aircraft rendered non-RVSM-approved shall normally be cleared out of the RVSM airspace by ATC when it is possible to do so. • Pilots shall inform ATC, as soon as practicable, of any restoration of the proper functioning of equipment required to meet the RVSM requirements. • The first ACC to become aware of a change in an aircraft's RVSM status shall coordinate with adjacent ACCs, as appropriate.

- When an aircraft operating in RVSM airspace encounters severe turbulence due to weather or wake vortex that the pilot believes will impact the aircraft's capability to maintain its cleared flight level, the pilot shall inform ATC. ATC shall establish either an appropriate horizontal separation or an increased minimum vertical separation.
- ATC shall, to the extent possible, accommodate pilot requests for flight level and/or route changes and shall pass on traffic information as required.
- When a meteorological forecast is predicting severe turbulence, ATC shall determine whether RVSM should be suspended and, if so, for how long and for which specific flight level(s) and/or area.
- ATC shall solicit reports from other aircraft to determine whether RVSM should be suspended entirely or within a specific flight level band and/or area.
- The ACC suspending RVSM shall coordinate such suspension(s) with, and any required adjustments to, sector capabilities with adjacent ACCs, as appropriate, to ensure an orderly progression to the transfer of traffic.
- In cases where RVSM will be suspended, the ACC suspending RVSM shall coordinate with adjacent ACCs with regard to the flight levels appropriate for the transfer of traffic, unless a contingency flight level allocation scheme has been determined by letter of agreement. The ACC suspending RVSM shall also coordinate applicable sector capabilities with adjacent ACCs as appropriate.

Table 3: Summary of Regional Supplementary Procedures related to RVSM

2.10 A summary of the responsibilities of States defined in Annex 8 Airworthiness of Aircraft are presented in **Table 4: Summary of Requirements for the Aircraft RVSM airworthiness.**

Annex 8, part II
The State establishes that continuing aircraft airworthiness determined through the periodical inspection at appropriate time interval having regard to lapse of time and type of service or, alternatively, by means of a system of inspection that will produce at least an equivalent result.
Any failure to maintain an aircraft in an airworthy condition as defined by the appropriate airworthiness requirements render the aircraft ineligible for operation
The State, where aircraft was registered, issues airworthiness certificate or updates ones certificate in accordance with [requirements associated with a Certificate of Airworthiness] The State, where aircraft was registered, establishes requirements, that the aircraft is suitable for the flights operating, in compliance with the technical maintenance requirement in accordance with Annex 6.

Table 4: Summary of Requirements for the Aircraft RVSM airworthiness

2.11 States should be aware that the requirements described above are applicable to all aircraft, including commercial, general aviation, military and other State designated aircraft, intending to operate under GAT rules with a 1,000 ft. vertical separation minimum in RVSM airspace. Non-approved State designated aircraft may request a clearance in RVSM airspace with a 2,000 ft. vertical separation minimum; however operators must declare non-RVSM on flight plans.

Regional Monitoring Agencies

2.12 A Regional Monitoring Agency is established by an ICAO Regional Planning Group to oversee the safety of operations in RVSM airspace. There are no formal regulatory requirements defining the

responsibilities of an RMA. Instead the RMA operates under Terms of Reference (ToR) agreed with the PIRG for implementation of monitoring functions to the required quality standard.

2.13 RMAs are expected to operate in accordance with the precepts of ICAO Doc. 9574 - *Manual on Implementation of a 1,000 ft. Vertical Separation Minimum between FL 290 and FL 410 Inclusive*. Guidance on the operation and procedures of an RMA are included in ICAO Doc. 9937 - *Operating Procedures and Practices for Regional Monitoring Agencies in Relation to the use of a 1,000 ft. Vertical Separation Minimum between FL 290 and FL 410 Inclusive*.

2.14 The principle activities of an RMA are to verify aircraft/operator RVSM approval status, conduct aircraft height keeping performance monitoring, verify the operator's compliance with the long-term monitoring requirements and provide annual airspace safety assessments. The RMA monitors aircraft/operator compliance within the precepts of ICAO Annex 6, reporting non-compliance and any associated safety issues to the States which retain the responsibility for ensuring that appropriate remedial action is taken. To perform this function it is essential that the States provide practical support to the RMA, particularly with regards to coordinating RVSM approval data exchanges and providing operational incident reports for inclusion in the annual safety assessments.

2.15 RMAs prepare RVSM annual safety reports which are presented to ARMA. Completed reports usually include:

- a) A quantitative assessment of the risk of mid-air collision attributable to the implementation of RVSM. This assessment includes both, technical risk attributable to aircraft technical height keeping performance, and total risk due to all causes including technical and human/operational errors
- b) A review of the major contributing factors which result in Large Height Deviations, with the purpose of reducing the number of risk bearing incidents.
- c) Any other safety related issues associated with the implementation or continued use of RVSM;
- d) Recommended measures to decrease risk with particular emphasis on improving aircraft height-keeping performance;
- e) Recommended measures to improve the safe operation of RVSM airspace; and
- f) Implement all applicable conclusions and decisions agreed by APIRG. Report non-compliance with APIRG conclusions and decisions by individual States, operators and service providers.

Monitoring Compliance with Requirements

2.16 This section provides an overview of the activities which the RMA and accredited States are required to conduct to provide an effective safety oversight and compliance monitoring infrastructure for Africa Indian Ocean RVSM airspace. It describes the high level functions of the monitoring programme and how these relate to the various responsibilities which are defined in the ICAO Annexes and global and regional procedures documents. Specific procedural detail for each of these functions is provided in the subsequent sections.

2.17 The major functional objectives of the monitoring programme are to, conduct technical aircraft height keeping performance monitoring, verify the approval status of aircraft and operators flying in RVSM airspace and conduct airspace safety assessments. For each of these functions to be conducted effectively it is

important that the Regional Monitoring Agency and accredited States operate in close cooperation, with each organisation fulfilling its obligations as determined by APIRG.

RVSM Approvals

2.18 Under the provisions of Annex 6 and the regional supplementary procedures all operators and aircraft intending to operate in RVSM airspace with a 1,000 ft. vertical separation are required to be approved by the State exercising operational authority over that aircraft and/or operator. Operators indicate that they hold a valid approval by filing a ‘W’ in item 10 of the ICAO flight plan. States are required to take appropriate action in the event that a non-approved operator/aircraft is found to be operating within RVSM airspace.

2.19 The practical task of monitoring aircraft/operator approval status is devolved to the RMA. For the RMA to perform this function effectively it is important that a complete inventory of aircraft approved to operate in Africa Indian Ocean RVSM airspace is maintained. The RMA maintains a central database of RVSM approved aircraft populated with records provided by individual States and other RMAs.

2.20 The RMA cross checks the central records of RVSM approvals against flight plans. A request for approval status of any unreported aircraft for which a ‘W’ has been inserted into the flight plan is sent to the appropriate State for confirmation of approval status. If the State confirms the approval then the record is added to the responsible RMAs database and no further action is required. In the event that the aircraft is not approved the State is required to take appropriate action, which may be to exclude the operator from operating in RVSM airspace until a valid approval has been issued.

2.21 To ensure an effective service and to minimise workload for both the RMA and individual authorities, States should ensure that the list of RVSM approvals for which it is responsible is kept up to date and communicated regularly to the RMA. States should also ensure that they have introduced procedures for receiving reports of possible non-approved aircraft from the RMA and conducting follow up investigations to verify the true status of the aircraft reported. In addition to transmitting new approvals to the RMA it is equally important that the RMA is informed when approvals are withdrawn or when aircraft are de- or re-registered. It has been demonstrated that the most effective mechanism is for each State to maintain a single centralised database of RVSM approvals which should be communicated to the RMA on a regular basis.

Aircraft Technical Height Monitoring Programme

2.22 Under the provisions of Annex 11 each RVSM region is required to maintain a technical height keeping performance monitoring programme. The specific requirements of the monitoring programme are defined in Annex 6 and RVSM guidance material and include; verification of individual aircraft altimetry system performance, verification of generic aircraft MASPS, operator compliance with fleet monitoring targets and finally to provide technical performance data for annual airspace safety assessments.

2.23 The RMA conducts technical height keeping performance monitoring which involves comparing measured aircraft geometric height data against actual geometric pressure altitude derived from meteorological data, provided by accredited meteorological international organisations. The monitoring systems in use include wide area ground based multilateration systems, individual on-board GPS measurement systems and ADS-B monitoring systems.

2.24 The RMA is responsible for submitting reports of individual aircraft which do not comply with performance requirements to the appropriate State authorities for remedial action. The RMA also submits reports of operators which do not meet biennial fleet monitoring targets, upon receipt of which States are also required to take appropriate action. In the event that the RMA determines that a specific aircraft type does not comply with the RVSM MASPS then this information is forwarded to the appropriate authority which issued the original aircraft airworthiness approval. The original airworthiness authority will then resolve any non-compliance with the aircraft manufacturer.

2.25 Data from the technical aircraft height keeping performance monitoring programme also contributes to the annual safety assessment, providing core data which is extrapolated for all RVSM airspace to provide a technical collision risk assessment which must satisfy a Target Level of Safety of 2.5×10^{-9} collisions per flight hour.

Operational Risk Events

2.26 The RMA is required to produce an annual RVSM safety assessment including a total collision risk assessment. The assessment consists of two elements which are the technical risk (as described above) and the risk due to operational issues such as aircraft altitude deviations and other risk bearing incidents such as incorrect coordination, communication errors and TCAS events.

2.27 The operational risk assessment relies on States to provide reports of operational incidents reinforced with specific event information when requested by the RMA.

RMA/State Interfaces

2.28 For the RVSM safety oversight and monitoring compliance programme to remain effective it is essential that the interfaces between the RMA and each accredited State are adequately defined and maintained. Each State should ensure that appropriate contact information is provided to the RMA. It is considered to be most effective for each State to provide a single contact point for communicating with the RMA for all RVSM matters. This contact is required to transmit all RVSM approval information to the RMA, receive and process; reports of non-approved aircraft; reports of technically non-compliant aircraft; reports of operators which are not compliant with fleet monitoring targets, and to submit operational event reports for inclusion in the annual RVSM safety assessment.

2.29 States should ensure that staff required to interface with the RMA are adequately trained and instructed in the various responsibilities required. In the event that individuals change work roles or leave the organisation it is essential that a complete handover to a replacement is completed so that there is no detrimental effect on the overall quality of service. In the event that it is not feasible to maintain single points of contact then it is necessary to ensure that the RMA is notified of all contacts and their respective responsibilities.

2.30 The operational framework including the accepted procedures to accomplish the monitoring programme objectives are discussed in more detail in the following sections.

3. RVSM APPROVAL PROCESSES

3.1 This section provides guidance and recommendations for the issuance and management of aircraft RVSM approvals by a State, and the coordination of that data with the RMA to which the State is accredited. It also describes the policies of the RMA with regard to compliance with approval requirements and how the information is shared with other RVSM regions.

3.2 A brief description of the constituent parts of the RVSM approval is provided below. In the following sections focus is given to the issues which particularly relate to maintenance of the approval, the conditions under which an approval may be considered to be valid and compliance monitoring in the post implementation environment.

3.3 There are a minimum of three constituent parts of an RVSM approval which are:

- Airworthiness Approval (MASPS): Confirmation that the build of an aircraft satisfies minimum equipment and height keeping performance requirements and that an appropriate maintenance programme has been developed by the manufacturer to maintain performance;
- Continued Airworthiness: Confirmation that the operator of an aircraft has instituted an appropriate continued airworthiness programme which should be based on the procedures developed by the manufacturer; and
- Operational Approval: Confirmation that the operator of an aircraft has instituted appropriate flight crew procedures for operations in RVSM airspace.

3.4 Detailed guidance material describing the recognised processes for the approval of the build of an aircraft is contained in ICAO Doc. 9574, FAA AC 91-85 and EASA AMC CS-ACNS, Annex I to ED Decision 2013/031/R. Additional material applicable to this document is provided in the next section.

3.5 The airworthiness approval is valid for all individual airframes produced to the same build standard and is normally issued by a single airworthiness authority. It is not considered necessary for subsequent approval authorities to re-confirm the airworthiness approval unless the aircraft has been modified or constructed to a Supplementary Type Certificate (STC) or equivalent build standard not covered by the original approval.

3.6 Unlike the Airworthiness Approval, the Continued Airworthiness and Operational Approval need to be issued by each individual approval authority, which must verify that the operator has instituted appropriate continued airworthiness procedures and that flight crews have been trained in RVSM operational procedures. The operational approval indicating valid areas of operation should be stated on the operator's AOC or in the pilot's flight manual. Once the approval authority is satisfied that all requirements have been met the State is required to notify the RMA that the aircraft in question meets all criteria for operations in RVSM airspace and is approved.

3.7 The airworthiness approval normally remains valid for the operational lifetime of an airframe, provided that the aircraft has been maintained in accordance with the manufacturers continued airworthiness procedures and that the aircraft is not subject to any modification which may require re-evaluation of the build standard. The continued airworthiness and operational approvals are operator specific and may not be transferred upon re-registration. Under certain circumstances it may be necessary to withdraw or re-issue an operational approval if the conditions under which the original approval was issued are no longer valid.

3.8 By issuing an approval to operate in RVSM airspace, a State is declaring that all contributing approval requirements are met including airworthiness approval, continued airworthiness approval and operational approval.

3.9 In the event that, following a report issued by the RMA, an aircraft is found to be operating in RVSM airspace with a ‘W’ designator, the State should make immediate contact with the operator concerned and where necessary issue instructions to cease flights in RVSM airspace. A review should be held into the circumstances under which the operator was operating without approval and appropriate action taken.

RVSM airworthiness approval

3.10 The aircraft airworthiness approval is normally granted by a single airworthiness authority and applies to a particular build standard which is defined by a specific Type Certificate (TC), Supplementary TC (STC), Service Bulletin (SB) or TC amendment. To obtain the approval, the manufacturer is required to submit an RVSM approval data package which is then evaluated in detail by the airworthiness authority prior to issuing the approval.

3.11 As a minimum the RVSM approval data package consists of the following:

- a) The applicable build standard to which the data package applies;
- b) A definition of the applicable flight envelopes;
- c) Data showing compliance with the RVSM performance criteria;
- d) The procedure to be used to ensure that all aircraft submitted for airworthiness approval comply with RVSM criteria. These procedures include the references of applicable Service Bulletins and the applicable approved aircraft flight manual amendment or supplement;
- e) The maintenance instructions that ensure continued airworthiness for RVSM approval.

3.12 RVSM performance data should include both measured and analytical data indicating the Static Source Error characteristics of the aircraft build standard and the corrections which must be applied to demonstrate the required performance.

3.13 Once a State (normally the State of manufacture or in the case of the EU, EASA) has issued an RVSM airworthiness approval for a specific build standard, it is not normally necessary for States issuing operational approvals for aircraft constructed to that same build standard to repeat the process. However, States issuing approvals to operators should verify that the build standard of an aircraft put forward for approval is the same as that referenced on the original RVSM airworthiness approval. This is particularly important when an aircraft is modified or built to an STC issued at a later date to that of the original airworthiness approval.

3.14 Particular attention should be given to aircraft built for special purpose roles, such as military applications, photographic or civilian survey missions. Procurement authorities are recommended to explicitly indicate whether an aircraft derivative is required to operate in an RVSM environment, with reduced separation minima, on the appropriate procurement specification and that such an individual RVSM solution is required to be demonstrated by submission of an RVSM approval data package.

3.15 In the event that an aircraft undergoes any structural or equipment modifications post airworthiness approval issue, then the original airworthiness approval may no longer be valid. States responsible for approving the modification must issue a new airworthiness approval based on a data package produced specifically for the modification. Revised aircraft performance data will need to be submitted to verify RVSM criteria compliance.

3.16 An aircraft which is constructed to a build standard with a generic RVSM airworthiness approval, and which exhibits common RVSM performance characteristics, is termed an RVSM Group certified aircraft. Any aircraft which is built or modified to a unique build standard with its own individual RVSM airworthiness approval, is termed an RVSM Non-Group aircraft. States must ensure that a full RVSM performance and analysis process is conducted on all individual Non-Group aircraft prior to issuing an RVSM approval. RMAs maintain a list of all recognised RVSM group definitions and can provide guidance on specific cases.

Validity of an RVSM operational approval

3.17 As the RVSM Operational Approval issued by a State includes verification of the operator's continued airworthiness and flight crew procedures, the approval cannot be transferred between operators. In the event that an operator changes its technical support structure (i.e. changes maintenance supplier) then it may be necessary to re-issue the approval.

3.18 Under certain circumstances it may be necessary to withdraw an RVSM approval from an operator. Such circumstances may include a breach of procedures, including Large Height Deviations, operator non-compliance with performance or fleet monitoring target requirements, or any other reason determined appropriate by the approval authority. Withdrawal of approval may apply to individual airframes or a complete fleet. Rarely, it may be necessary for the original airworthiness authority to withdraw approval for a complete build standard.

3.19 In accordance with paragraph 3.2.3 of Annex 8 to the Convention on International Civil Aviation, the State Authority should ensure a periodic inspection to demonstrate that the RVSM airworthiness remains valid, and that the aircraft and operator remain in compliance with the established requirements. As part of the height keeping performance monitoring programme the RMA conducts trend analysis and can assist in monitoring the efficacy of an operator's RVSM continuous airworthiness procedures. If RVSM continuous airworthiness procedures are determined to be inadequate the RVSM approval may be considered to be invalid.

3.20 In accordance with the requirements of Annex 6 any aircraft that operates with a reduced separation minima in RVSM airspace must hold a valid RVSM approval. Similarly, any aircraft which is non-compliant with Altimetry System Error requirements (due to inadequate RVSM continuous airworthiness procedures) can be considered to be non-compliant with general airworthiness requirements defined in Annex 8, paragraph 3.2.8. Under the precepts of this requirement, any non-compliance renders the aircraft ineligible for operation.

3.21 State authorities should also consider the RVSM approval status of any aircraft/operator under the following circumstances:

- a) The conditions under which an initial approval was issued have changed. For example, the construction or equipment configuration of the aircraft has been changed such that the original RVSM data approval package is no longer valid;
- b) The operator is not in compliance with the long-term monitoring requirements, and so cannot demonstrate the effectiveness of continued airworthiness procedures.

3.22 In such circumstances as those described above, the State should satisfy itself that corrective action has been taken before the aircraft is permitted to continue operations in RVSM airspace. Such action may include submission of a new RVSM approval data package, but in all cases should include height monitoring in accordance with a plan agreed between the State and operator and coordinated with the RMA. Such a monitoring programme should demonstrate compliance with all airworthiness requirements within a reasonable time frame which should not exceed 6 months. Failure to comply with an agreed monitoring plan should result in the removal of the RVSM type approval for the operator (i.e. removal of approval for all airframes of the type for which the operator is non-compliant with monitoring targets).

3.23 There is no formal requirement to limit the duration of an RVSM approval; however many States have implemented a two year limit to ensure that operators comply with all height monitoring requirements before a renewal is issued. States which do not issue an approval with such a limitation should ensure that they have initiated procedures to ensure that operators continue to comply with all height monitoring requirements. It is recommended that all States should adopt a policy of issuing approvals with fixed expiration dates and that authorities implement procedures to verify continued compliance with all height monitoring requirements before a renewal is issued. An operator with an expired approval shall be treated identically to an operator flying with no approval and reported for non-compliance with Africa Indian Ocean flight rules.

3.24 In the event that an aircraft is re-registered then the approval issued to the original operator shall be automatically cancelled. Aircraft which are dry-leased, i.e. leased to a third party operator (lessee) who provides their own crew, shall not be operated on an approval issued to the owner/operator (lessor).

3.25 Any aircraft/operator found to be operating as RVSM approved, without an approval being issued by the State exercising operational authority, with an expired approval, or with an approval issued to another operator or registration shall be reported as non-approved to the State exercising operational authority and any other States in whose airspace the aircraft may be operating. It remains the responsibility of individual States to ensure that appropriate action is taken with operators of non-approved aircraft.

RVSM approvals - RMA

3.26 Aircraft approval status verification is delegated to the accredited RMA. The RMA maintains a database of aircraft which is populated with approval records submitted by State representatives and RMAs from other RVSM regions.

3.27 The RMA conducts regular audits of flight plans, comparing the registrations of aircraft from flight plans in which RVSM approval has been indicated, to records contained in the RMA database of approvals. The RMA will submit a request to the appropriate State authority if an aircraft which is not listed in the database is found to be operating as RVSM approved. If the aircraft is subsequently confirmed as holding a valid approval then its details are added to the database. If the aircraft is not approved then it remains the responsibility of the State to take appropriate action, which may be to instruct the operator to cease flying in RVSM airspace until a valid approval has been issued.

3.28 The RMA functions as a monitoring and reporting agency only. The RMA is not responsible for verifying that any conditions applicable to an RVSM approval issued by a State are met; however the RMA may require clarification if an aircraft is not recognised as an RVSM type. In addition the RMA is not responsible for verifying that the operator is compliant with any operational limitation defined on the AOC or flight manual, or that the aircraft is being flown by the operator or crew to whom the approval has been issued.

3.29 It is the responsibility of individual States to implement processes and procedures to verify that aircraft construction, equipment, performance, maintenance instructions and crew training all comply with the RVSM regulatory requirements. The RMA cannot be involved in the internal approval process. Specifically height monitoring data cannot be used in lieu of certified and calibrated SSE measurement systems, operated under controlled conditions, to provide engineering substantiation of aircraft height keeping performance.

3.30 Non-approved aircraft present potential safety threats in RVSM airspace and so need to be identified and appropriate action taken in an expeditious manner. To improve the effectiveness of the RMA and to avoid unnecessary investigations it is important that States support the RMA by ensuring that the records of RVSM approvals are correct and up to date. Errors in the database result in unnecessary workload for both the RMA and State authority.

3.31 States can report individual aircraft approvals to the RMA using form F2 available on each RMA's website.

3.32 An RVSM approval shall be considered valid indefinitely unless a State issues a specific expiry date or until the State informs the RMA that an approval is no longer valid (i.e. the aircraft has been re-registered, placed in indefinite storage, scrapped, or the approval is withdrawn for any other reason). The RMA will not accept a transfer of an RVSM approval between operators. Upon a change of operator the RMA will remove the approval confirmation until a new approval is issued. The RMA will not accept RVSM approvals directly from operators.

3.33 In addition to conducting audits of flight plans within its own accredited area of responsibility, an RMA may be requested to confirm the approval status of an aircraft operating in another RVSM region. The RMA will forward all such requests to the appropriate State authority.

3.34 Aircraft which are confirmed as non-approved will be reported as such to the States where they were operating. This information will also be available to States within the region.

3.35 To maintain an accurate database of approvals the RMA will periodically request a State to participate in an audit of the full list, or inventory, of approvals for which the State is responsible.

3.36 A structured approach to approvals management and efficient State/RMA coordination procedures is important to ensure the effectiveness of the safety oversight programme. Any breakdown in coordination may result in increased workload and distraction from addressing priority safety issues and may be referenced in the annual ARMA Report presented by the ARMA toAPIRG.

RVSM approvals - States

3.37 In accordance with the precepts of ICAO Annex 6, States are the principle authorities, tasked with ensuring that all aircraft under their operational authority, intending to operate in RVSM airspace, are approved. States are required to ensure that aircraft/operators continue to comply with performance and fleet monitoring target requirements. States are also required to take appropriate action with operators of non-approved aircraft found to be operating within their sovereign airspace.

3.38 States should ensure that a list of personnel authorised to issue notifications of RVSM approvals to the RMA are supplied beforehand. States can submit relevant contact information using form F1 available on each RMA's website.

3.39 To minimise workload and to avoid aircraft being incorrectly identified as non-approved it is important that States have processes and procedures in place to enable the easy verification of the status of any aircraft for which they exercise operational authority. It is recommended that each State implement a centralised database of approvals which can be periodically cross checked with the RMA database.

3.40 States must ensure that they have implemented processes and procedures to respond to requests for approval status confirmation received from the RMA and that appropriate action is taken with operators of any aircraft which are found to be operating without approval. Expedious responses to RMA requests are necessary to avoid aircraft being incorrectly labelled as non-approved.

3.41 States should ensure that RVSM approvals are issued prior to operators commencing flights in RVSM airspace. This applies to delivery and ferry flights as well as normal operations. To minimise workload and avoid unnecessary investigative actions, States should ensure that new approval records together with any changes to existing records are forwarded to the RMA with minimum delay. States should pay particular attention to ensure that the RMA is notified when an aircraft is re-registered, removed from service, changes operator or any other situation which may affect the RVSM approval status. Regular cross checks between the RMA and States are necessary to maintain the currency of the region's approvals and to minimise unnecessary workload.

3.42 It is recommended that in the event that an operator is found to be flying in RVSM airspace without approval then they should be instructed to cease filing flight plans with ‘W’ in item 10 with immediate effect. Furthermore the State should investigate the circumstances under which the operator was conducting such flights and either, implement procedural changes where necessary, or take appropriate action in the event of wilful action on the part of the operator.

3.43 States should also consider the approval status of any aircraft/operator which does not comply with performance or fleet monitoring target requirements, as reported by the RMA. States which issue expiry dates should ensure that aircraft/operators are fully compliant with all requirements before any approval extension is issued. It is important that States ensure that they have instituted procedures to ensure appropriate action is taken with operators of aircraft with approvals due for expiration. An aircraft with an expired approval shall be considered as non-approved.

3.44 Upon receipt of any report involving a failure to adhere to RVSM in-flight crew procedures, the State should ensure the investigation of the circumstances of the incident. Where appropriate the State should ensure that remedial training has been implemented to avoid future repetitions and depending on the severity, or frequency, of incidents should consider withdrawal of the operator’s RVSM approval.

3.45 In addition to taking appropriate action with any non-compliant aircraft/operator, it may be necessary for a State to implement a review of its own internal approval processes which may have inadvertently contributed to any aircraft/operator non-compliance. Such situations may include:

- Issuing an approval based on an invalid RVSM approval data package (for example when an aircraft is constructed to an STC when the data package is only valid for aircraft constructed to the original TC);
- Inadequate, inappropriate or overdue response upon receipt of a non-compliance by the accredited RMA;
- Lack of operator familiarity with RVSM flight crew procedures or approval requirements;
- Inadequate configuration management control of RVSM approval information including data coordination with the accredited RMA.

RVSM approvals – Flight planning

3.46 All operators of RVSM approved aircraft indicate that a particular aircraft is RVSM approved by filing a ‘W’ in item 10 of the ICAO flight plan (including State approved aircraft). Any filing of the ‘W’ by a non-approved aircraft is in contravention of ICAO Doc. 7030.

3.47 State aircraft which are not RVSM approved may be permitted to operate in RVSM airspace with a 2,000 ft. vertical separation minimum; however they must not file a ‘W’ in the flight plan and must indicate STS/NONRVSM in item 18 of the flight plan. Only military, customs and police may file flight plans as State aircraft. Formation flights are not permitted in RVSM airspace even if the individual aircraft themselves are RVSM approved.

3.48 No civilian non-approved aircraft will normally not be provided with an ATC clearance into RVSM airspace with the exception of designated airspaces in the Africa Indian Ocean region where non-approved civilian aircraft are permitted to operate. States are required by the precepts of ICAO Annex 6 to take appropriate action with aircraft/operators found to be operating in RVSM airspace without approval. Operators should ensure that flight plan dispatchers have accurate information regarding the RVSM approval status of all aircraft within a fleet so that incorrect approval status is not entered into the flight plan.

RMA action of non-approved and non-compliant aircraft

3.49 Under the precepts of ICAO Annex 6 a State is required to take appropriate action in the event that an aircraft for which it exercises operational authority is found to be operating in RVSM airspace without approval. In addition, a State is also required to take appropriate action against any non-approved aircraft, irrespective of the State of origin, which may be operating within the airspace of the State concerned. The monitoring of this second requirement is problematic for many States as there is no reference document or system which can be easily accessed to confirm the approval status of all aircraft operating within their airspace.

4. RMA/STATE COORDINATION

RMA contacts

4.1 An RMA is established to support States to demonstrate compliance with ongoing safety oversight and airspace monitoring requirements in RVSM airspace. The RMA in the Africa Indian Ocean region represent 48 States. As the RMA is responsible for managing RVSM approvals (both civil and military), addressing RVSM airworthiness issues and processing operational event reports for risk assessment, it is often necessary for a State to provide multiple contacts to the RMA. Therefore the RMA may be required to maintain connections with a number of individual points of contact within its area of accreditation. The RMA must also maintain communication with all other RMAs which represent the different RVSM regions around the world as well as aircraft manufacturers and regulatory bodies.

4.2 The data communications traffic for the RMA is relatively high so it is important that the RMA is aware of the credentials and responsibility/authority of any individual with which it communicates; particularly as some data exchanges involve sensitive and confidential information. The RMA does not encourage direct communication with operators except by prior arrangement and not for the purposes of RVSM approval exchange. Communication with operators is normally limited to confirmation of availability of height monitoring systems and the provision of height monitoring data (also by prior arrangement). The RMA does not accept direct communications from operators or States from other RVSM regions, requesting that all such communications be directed through the host RMA, who can often provide the appropriate information without reference to other RMAs.

4.3 Each RMA provides a generic e-mail address to which all information and requests for data and assistance should first be directed. The RMA will review each message and redirect to a specialist if necessary. All messages to the RMA will be acknowledged and if appropriate a dialogue will be initiated either through the generic e-mail address or by a specialist in the area of discussion.

4.4 The RMA is not operational ATC units and therefore are normally manned during regular working hours only.

State contacts

4.5 To provide a coordinated and effective safety oversight and monitoring programme for RVSM in Africa Indian Ocean it is important that each State delegates specific units and/or individuals to interface directly with the RMA to which it is accredited. States should ensure that official points of contact are clearly identified and reported to the RMA. States should ensure that authorised points of contact are notified to the RMA for the following areas:

- a) Exchanging RVSM approval information with the RMA on a regular basis;

- b) Managing requests for approval status confirmation received from the RMA and taking appropriate action with operators of non-approved aircraft;
- c) Managing reports received from the RMA of aberrant and non-compliant aircraft Altimetry System Error and other airworthiness issues;
- d) Addressing operator non-compliance with fleet monitoring targets received from the RMA;
- e) Collating and distributing operational incident reports in RVSM airspace;
- f) Providing flight plan traffic sample data to support the annual RVSM safety assessment. (as defined in ICAO Doc. 9937)

4.7 It is desirable to minimise the number of contacts from each State with which the RMA has to coordinate actions; however in the majority of cases it is accepted that two or more points of contact may be required to ensure appropriate expertise is available for each of the functions described above.

4.8 To avoid misunderstanding and the delay in verifying credentials following communications from unknown contacts, States should submit all authorised points of contact to their accredited RMA using F1 form available on each RMA's website.

4.9 It is important that each State ensures that responsibilities are transferred and new RMA F1 forms issued in the event of staff leaving or changing position so that continuity of service with the RMA is maintained.

Inappropriate State Actions

4.10 Effective oversight and resolution of safety issues in RVSM airspace can only be achieved if the RMA and its accredited States function together to ensure that RVSM data is accurate and that appropriate follow up actions are taken in an expeditious manner. It is particularly important that States ensure that appropriate remedial action is taken as quickly as possible in the event that the RMA submits a report requiring State action.

4.11 In the event that a State does not take action which is considered appropriate with any non-approved or non-compliant aircraft/operator, then the RMA shall propose to the ARMA to subsequently propose the State to be included in the AFI Air Navigations Deficiencies Database (AANDD) to the APIRG.

5. TECHNICAL HEIGHT KEEPING PERFORMANCE AND MONITORING

5.1 A major part of the RVSM safety oversight programme involves monitoring aircraft technical height keeping performance, or more specifically, aircraft Altimetry System Error (ASE). ASE is the difference between the altitude indicated by the altimeter display, assuming a correct altimeter barometric setting and the pressure altitude corresponding to the undisturbed ambient pressure; or described more simply as the difference between the actual altitude of the aircraft and the indicated altitude of the aircraft. Any aircraft flying at an incorrect level presents a threat to air safety; however ASE is particularly dangerous as the effect is frequently invisible to pilots, ground controllers and aircraft collision avoidance systems such as TCAS.

5.2 A major contributor to ASE is the Static Source Error (SSE), which is the error introduced, when attempting to measure the ambient air pressure, caused by the physical presence of the aircraft itself. The SSE characteristic is a variable influenced by a number of parameters including, airframe design and configuration, speed, altitude, weight and attitude of the aircraft. The SSE characteristic of an airframe is modelled at the design phase with corrections applied in the aircraft's avionics system which are intended to remove its effects. However, the SSE characteristic can change over time due to a number of factors including, degradation of sensor components, physical damage to sensor probes or static ports, blockages of the pressure system, or aircraft modifications. In the event that the SSE characteristic changes then the corrections applied in the avionics may no longer be valid, resulting in increased ASE. Validated continuous airworthiness programmes are essential to ensure any changes to SSE are detected and corrected.

5.3 The purpose of the height monitoring programme is to verify that the initial Static Source Error Corrections (SSEC) remains valid, that the continuous airworthiness programmes are adequate and that operators have implemented such programmes correctly. Biennial minimum monitoring targets for all operators of RVSM approved aircraft are defined in ICAO Annex 6 to ensure correct application of continuous airworthiness programmes; however increased quantities of monitoring are required when a new RVSM type or variant is developed until such time as the initial and long term ASE characteristic of the design has been confirmed. The actual monitoring target for any operator of an RVSM approved aircraft is therefore determined by the type of aircraft. The monitoring requirements for all RVSM approved aircraft, variants and derivations are defined in a table revised annually by the ICAO RMA Coordination Group (RMACG). Copies of the latest MMR can be obtained from the RMA to which a State is accredited.

5.4 The accurate measurement of ASE requires the use of precise and calibrated specialist equipment operated under controlled conditions, and is an expensive process which is normally only performed at the initial airworthiness stage. It is not feasible to expect all operators of RVSM approved aircraft to undergo repeated flight checks under these controlled conditions to demonstrate continued compliance with ASE performance requirements. A number of alternative systems have been developed which provide accurate estimates of aircraft ASE under most conditions. The major advantage of these systems is that they can operate with little or no active participation on the part of the operator and are transparent to the crew. A brief description of techniques employed by RMAs to estimate aircraft ASE characteristics is provided in the following section.

Height Monitoring Systems

5.5 There are three independent height monitoring systems currently in use. These are:

- GPS Monitoring Unit (GMU). This is a portable carry on device used to estimate the ASE of a single flight for one aircraft. The advantage is that the aircraft can be monitored almost anywhere that it is scheduled to operate; however the operating and processing costs for the operator are high as they rely on dedicated resources;
- Height Monitoring Unit (HMU). An HMU is a fixed ground based system which with one central and four outer receiving stations. The HMU measures geometric height of an aircraft

using the multilateration principle. Multilateration obtains three-dimensional positions calculated from the time difference of arrival (TDOA) of signals at each receiving stations from the transponder of an aircraft in flight. At least four receiving stations are required, and the fifth improves omni-directional coverage, accuracy and system redundancy. The coverage of an HMU is approximately 30 – 50 NM radius; and,

- **ADS-B Height Monitoring Systems (AHMS).** An Automatic dependent surveillance-broadcast (ADS-B) Height Monitoring System (AHMS) is a height monitoring system that utilizes data from an existing ADS-B network. It uses geometric height data available from ADS-B equipped aircraft in order to calculate the ASE. The coverage of an AHMS depends on the coverage of the ADS-B network it obtains data from.

5.6 There are advantages and disadvantages to all the monitoring systems; however they all operate on the same fundamental principle, which is the comparison of the true height of an aircraft against the height of the pressure level which corresponds to the indicated altitude of the aircraft. The implementation of such a system is however quite complex. For GMUs, the height of the aircraft is provided by the GPS receiver of the on-board GMU. For an AHMS, the height of the aircraft is obtained from the aircraft's GPS receivers. An HMU, on the other hand, relies on the estimation of the aircraft height using multilateration techniques. The determination of the height of the pressure level which corresponds to the indicated altitude of the aircraft is challenging as the pressure levels move up and down depending on the specific meteorological conditions and vary in magnitude over both time and position. Various methods of modelling the continually changing height of the pressure level have been implemented; however they all rely on an initial set of values obtained from various Numerical Weather Prediction models (NWP) provided by national and international meteorological organisations.

5.7 It is important to ensure that the monitoring data is correlated to the correct aircraft. Height monitoring systems only receive the aircraft ICAO 24-bit aircraft identifier. It is necessary to compare the 24-bit aircraft address to the address provided by the State in the RVSM approval data. If the transmitted address is different from the one recorded by the RMA then the monitoring result will not be correlated to the correct aircraft.

Operator Long Term Height Monitoring Programme

5.8 All operators of RVSM approved aircraft are required to participate in the RVSM height monitoring programme. The principle purposes of the long term height monitoring programme are to verify long term ASE stability and the efficacy of an operator's continued airworthiness programme.

5.9 All operators of RVSM approved aircraft in the Africa Indian Ocean (AFI) Region should comply with the recommended Long Term Height Monitoring requirements (LTHM) defined in the current version of the MMR. Data from any of the recognised RVSM monitoring programmes may be used to satisfy an operator's monitoring target. The monitoring target varies dependent on the total amount and quality of monitoring data available, the period over which time such data was obtained and the quality of the performance data. For aircraft designs which have been monitored, with statistically representative data samples demonstrating stable performance, for in excess of two years, the requirement is for all operators to have a minimum of two aircraft monitored every two years or 1,000 flight hours, whichever the greater. For aircraft designs which have received a generic RVSM airworthiness approval within the last two years operators are required to have 60% of their fleets monitored every two years or 1,000 flight hours, whichever the greater. Finally if an aircraft is modified or built to a unique design and presented for RVSM airworthiness approval on an individual basis then that aircraft is required to be monitored every two years or 1,000 flight hours, whichever the greater.

5.10 States should ensure that all operators of RVSM approved aircraft under their operational authority comply with the minimum fleet monitoring targets. States should ensure that operators have

implemented plans to demonstrate compliance with LTHM requirements and that the targets are met in the time frame required. States should take appropriate action with any operator which fails to comply with the LTHM requirements. Such appropriate action includes temporary revocation or suspension of an approval, complete withdrawal of approval and refusing an extension in the event that an approval has expired.

5.11 The RMAs conduct regular assessments of operator compliance with monitoring targets, the results of which are forwarded to the various State authorities which have the responsibility for determining what further action should be taken. Operators are encouraged to contact the RMA to check availability and flight requirements for the various height monitoring programmes prior to conducting any dedicated monitoring flights.

ASE Performance Investigations

5.12 ASE data acquired from the height monitoring programmes are used in three ways by the RMA. The total data sample provides the input to the technical collision risk assessment conducted annually by the RMA and presented to ARMA and the APIRG. Data is also grouped by aircraft type and individual airframe generic and discrete airframe ASE performance.

5.13 The ICAO Annexes and the various MASPS documents define the maximum tolerable ASE performance requirements for both RVSM groups (i.e. the total population of aircraft built to a common compliance standard), and individual airframes, in order to comply with the technical safety limits. The principle requirements are described below:

- The mean ASE of any RVSM group shall be less than ± 80 ft.
- The mean plus 3 standard deviations of any RVSM group shall be less than 245 ft.
- The ASE of any individual airframe shall be less than ± 245 ft.

5.14 The RMA collects the measurement results and conducts regular analysis of both group and individual airframe performance. In the event that the group performance results, taking into account the size of the available data sample, indicate non-compliance with one or both of the requirements defined above then it requests a more detailed investigation by the Authority responsible for issuing the original airworthiness certificate. The resolution of any generic RVSM group investigation may be time consuming and expensive. Actions to resolve a generic performance investigation may include design changes, re-calculation of SSEC or amendments to continuous airworthiness procedures. Although removal of a generic RVSM airworthiness approval remains the ultimate sanction of any authority, the implications for both the manufacturer and existing operators would be extremely serious making this an unlikely scenario in all but the most extreme cases which impact safety separation standards.

5.15 More common than a group investigation is an investigation into the performance of an individual aircraft which exhibits non-compliant ASE performance due to damage or degradation of a component within the static pressure system. In addition to reporting an aircraft which is not compliant with the absolute ASE limit, the RMA monitors performance which is not consistent with the core distribution of aircraft and which may be in the early stages of deterioration towards becoming non-compliant. Such performance is termed aberrant.

5.16 Any aircraft which exhibits performance which is not compliant with the ASE performance requirements defined above is subject to a mandatory report submitted to the appropriate State authority for immediate action. An RMA may recommend a State or operator to investigate the performance of an aircraft which is aberrant if the typical performance is over a pre-set limit (typically 200 ft.) or if the ASE characteristic indicates a significant trend towards non-compliance. States are urged to formulate a course of action in regards to an aircraft reported as being non-compliant.

5.17 Although the RMA may institute an investigation into a non-compliant or aberrant aircraft, it remains the responsibility of the appropriate State authority to ensure that the case is investigated and resolved to its own satisfaction. The RMA can provide assistance and guidance, either directly advising the operator or as consultant to the State. Upon confirmation that remedial action has been completed the RMA will liaise with the State to decide if the investigation can be closed. Additional monitoring should be conducted to ensure any remedial action has been successful. The problems most commonly associated with poor ASE performance include the following:

- Humidity, leaks or corrosion in static pressure lines.
- Damage, blockage corrosion to static vents, pitot heads or probes.
- Air flow disturbance in area of static sensors due to paint damage, contamination or other physical changes.
- Airframe skin waviness effects.
- Angle of Attack vanes stiff or out of tolerance.
- TAT units out of tolerance.
- Air Data Computers out of tolerance.
- Damage to pressure transducers.
- Invalid SSEC.
- Invalid MASPS compliance

5.18 Any aircraft which fails to meet the technical vertical navigation performance requirements, particularly with regards to Altimetry System Error, represents a risk to maintaining vertical separation between aircraft. Following the receipt of a report of large ASE the State authority should be expected to take action proportional to the magnitude and characteristic of the non-compliance.

- An individual non-compliant ASE result considered to be inconsistent with typical performance for that airframe and which has subsequently returned to normal levels. The State should investigate the circumstances of the problem and if necessary implement changes to operational and continuous airworthiness procedures. Dependent on the severity of the problem the operator may be permitted to continue operations in RVSM airspace during the investigation.
- An individual or multiple non-compliant ASE results considered to be representative of typical performance for that airframe. The State should withdraw the RVSM approval until an investigation into the problem is completed and the operator can demonstrate that the non-compliance has been resolved. In the event that non-compliance is due to aircraft modification, equipment change etc., then it may be necessary to re-evaluate the entire RVSM approval data package for the aircraft concerned, prior to issuing a new approval.
- A generic RVSM group fails to comply with group performance requirements. The State which issued the original airworthiness approval for the type should actively investigate the circumstances and if necessary withdraw the type approval until resolved.

6. ALTITUDE DEVIATION AND OTHER OPERATIONAL REPORTS

6.1 A key safety objective of the Africa Indian Ocean RVSM monitoring programme is the estimation of collision risk due to technical and operational reasons. The collision risk estimation process is complex and not within the scope of this document. The key parameters for the collision risk assessment are deviations from assigned (or planned/expected) flight levels, including both the magnitude and the duration of events, and the aircraft dimensions.

6.2 The technical risk assessment is conducted using monitoring data which is considered to be generic and so can be extrapolated for the entire population of aircraft throughout the region. The required magnitude and duration parameters are embedded in the data itself and the aircraft dimensions available once the monitoring result is correlated to a known registration.

6.3 The calculation of the operational risk is similar in concept; however the data can only be supplied from operational units and is dependent on the specific operational environment and air situation at the time of the event. Each operational risk event is unique in nature and therefore it is not possible to extrapolate the parameters derived from one event to other areas of the region. To enable the RMA to provide a reasonable estimate of risk due to operational factors it is important that all accredited States institute processes to collect operational incident reports and forward the relevant information to the RMA for inclusion in the risk assessment process.

6.4 The following sections describe the information which is required by the RMA to conduct the collision risk estimate and the definitions of events which should be reported.

Description of Operational Events

6.5 Altitude deviations and sudden unplanned alterations to ATC clearances inherently carry a greater risk in areas in which a reduced vertical separation minimum has been implemented. It is therefore important that an assessment is periodically conducted to ensure that collision risk estimates satisfy pre-defined Target Levels of Safety (TLS).

6.6 The RMA conducts operational environment collision risk estimates using data provided by accredited member States. An event is reportable to the RMA when either an aircraft makes a deviation from a cleared level between FL 280 and FL 420 (cleared or actual) or an ATC clearance results in a risk bearing situation, such as loss of separation or TCAS initiated deviation.

6.7 The range of factors which may result in a reportable event include the following:

- Pilot not following an ATC clearance resulting in flight at unassigned flight level;
- Unexpected rate of climb/descent resulting in exceeding or not achieving cleared flight level;
- Pilot not following established contingency procedures for emergency descent;
- Technical failure in the altimetry or automatic altitude control system of an aircraft;
- Turbulence or other weather related phenomena;
- Response to airborne collision avoidance system resolution advisory;
- An error in issuing an ATC clearance which results in flight at incorrect level or which impairs separation minima;

- Coordination errors between adjacent ATC units in the transfer of control responsibility for an aircraft resulting in flight at an incorrect or unexpected flight level;
- Communication loop errors, (undetected or garbled read back/feedback errors).

6.8 The important parameters which must be available if the report is to be used for the quantifiable risk assessment include the magnitude of deviation and duration. It is possible that a single event will have multiple phases each with its own set of parameters. As much information as possible should be provided on the report to assist in the estimation of the required parameters and nature of the event.

Reporting of Operational Events

6.9 A number of methodologies are available for estimating the collision risk parameters due to operational events. These may include follow up investigations to determine the nature of any deviation, and/or the receipt and analysis of dedicated operational incident reports, or large Height Deviations. In both methodologies it is essential that individual States provide the operational event reports to the accredited RMA.

6.10 If a State submits operational incident reports it is important to ensure that the following minimum information is provided:

- High level description of event including category from list provided in section 6.7.
- Aircraft type and identity.
- Location.
- Magnitude of vertical error or deviation (for each phase of event if applicable), which may also be reported as expected flight level, and actual or observed flight level.
- Duration of deviation (for each phase of event if applicable).

6.11 The RMA can provide copies of preformatted forms for the purposes of reporting operational incidents. Please note that each individual RMA may arrange a different mechanism for the reporting such as an e-mail submission or on an online form on the ARMA website.

6.12 The RMA is responsible for reviewing all operational incident reports and compiling the parameters for the collision risk analysis. If a report does not include the minimum information required then the report may not be included in the assessment. In the event that some information is missing the RMA may, based on previous reports and experience, include an estimate for a parameter so that the report may contribute to the risk assessment. If appropriate the RMA may also send a request to the operator directly or through another RMA to clarify the contributory causes of a large height deviation. On the basis of internal investigation the operator should reply to the RMA's request and provide information regarding the cause of any large height deviation. The RMA will clearly distinguish between parameters which have been submitted on reports and those which are estimates based on the evidence available.

6.13 In some RVSM regions special arrangements may be made for the submission of RVSM operational incident reports through other safety oversight programmes.

– END –

**Regional Monitoring Agencies Operating in the
International Civil Aviation Organization (ICAO) Africa Indian Ocean Region**



APPENDIX B –APIRG CONCLUSIONS AND DECISIONS

APIRG Conclusions (Up to the 25thAPIRG)

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APPENDIX C – LHD/LLE/LLD TAXONOMY

Note: the LLE/LLD Taxonomy are not part of RVSM monitoring but are provided in this document for ease of reference.

LHD Code	LHD Category Description
A	Flight crew failing to climb/descend the aircraft as cleared
B	Flight crew climbing /descending without ATC clearance
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance, etc.)
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level)
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. late or non-existent coordination of flight level)
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure);
H	Airborne equipment failure leading to unintentional or undetected change of flight level (e.g. altimetry errors)
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level
J	TCAS resolution advisory; flight crew correctly climb or descend following the resolution advisory
K	TCAS resolution advisory; flight crew incorrectly climb or descend following the resolution advisory
L	An aircraft being provided with RVSM separation is not RVSM approved (e.g. flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan)
M	Others

Table 1: LHD Taxonomy

LLE/ LLD Code	LLE and LLD Category Description
A	Flight crew deviate without ATC Clearance in the horizontal dimension
B	Incorrect estimate or route provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance, original clearance followed instead of re-clearance in FMS, incorrect time estimate sourced from flight deck, etc.)
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position
D	ATC system loop error (e.g. ATC issues incorrect route clearance, Flight crew misunderstands route clearance message, etc.)
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination,

	incorrect time estimate/actual, ATS route, etc. not in accordance with agreed parameters)
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. non-existent coordination, incorrect time estimate, or ATS route attributed to technical causes)
G	Navigation errors due to airborne equipment failure leading to a deviation in the horizontal dimension of which notification was not received by ATC or notified too late for action
H	Turbulence or other weather related causes (other than approved) leading to a deviation in the horizontal dimension
I	An aircraft was provided with reduced horizontal separation minima but did not meet the RNP/RSP/RCP specification;
J	Others

Table 2: LLE/LLD Taxonomy