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## **REDUCED VERTICAL SEPARATION MINIMUM (RVSM)**

### **1.0 PURPOSE**

This Advisory Circular (AC) provides information and guidance material that should be used by air operator certificate (AOC) holders to ensure compliance with RVSM regulatory requirements. The AC also provides background information for operators to assist them in ensuring they meet continuing airworthiness requirements for RVSM approved aircraft and operations requirements for flight in RVSM airspace.

### **2.0 REFERENCE**

- 2.1 Civil Aviation (Instruments and Equipment) Regulations, as amended  
  
Civil Aviation (Operation of Aircraft- Commercial Air Transport) Regulations, 2018, Regulation 7 and 131, 132
- 2.2 FORM: AC-OPS029 - RVSM Application Form
- 2.3 ICAO Doc 9574 — Manual on 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive;
- 2.4 Joint Aviation Authority (JAA) Temporary Guidance Leaflet (TGL) No. 6 — Guidance Material on the Approval of Aircraft and Operators for Flight in Airspace above Flight Level 290 where a 300 m (1 000 ft) Vertical Separation Minimum is Applied — or any subsequent version thereof;
- 2.5 Federal Aviation Administration (FAA) Document 91-RVSM, Guidance Material on the Approval of Operators/Aircraft for RVSM Operations, as amended.

### **3.0 INTRODUCTION**

Civil Aviation (Operation of Aircraft- Commercial Air Transport) Regulations, 2018, Regulation 131 (7) requires that prior to granting (RVSM) approval the Authority shall be satisfied that-

- (a) the vertical navigation performance capability of the aircraft satisfies the requirements of the altimetry system performance for operations in RVSM airspace as prescribed by the Authority;
- (b) the operator has instituted appropriate procedures in respect of continued airworthiness (maintenance and repair) practices and programmes; and

(c) the operator has instituted appropriate flight crew procedures for operations in RVSM airspace.

In addition Civil Aviation (Operation of Aircraft- Commercial Air Transport) Regulations, 2018, Regulation 132 (1) requires that a minimum of two aeroplanes of each aircraft type grouping of the owner or 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.

## **4.0 TERMINOLOGY**

### **4.1 Definitions**

The following definitions are intended to clarify certain specialized terms used in this manual.

**Aberrant aircraft.** Those aircraft which exhibit measured height-keeping performance that is significantly different from the core height-keeping performance measured for the whole population of aircraft operating in RVSM airspace.

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

**Airworthiness approval.** The process of assuring the State authority that aircraft meet an RVSM MASPS. Typically, this would involve an operator meeting the requirements of the aircraft manufacturer service bulletin for that aircraft and having the State authority verify the successful completion of that work.

**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.

**Altimetry system error stability.** Altimetry system error for an individual aircraft is considered to be stable if the statistical distribution of altimetry system error is within agreed limits over an agreed period of time.

**Altitude-keeping device.** Any equipment which is designed to automatically control the aircraft to a referenced pressure altitude.

**Assigned altitude deviation (AAD).** The difference between the transponder Mode C altitude and the assigned altitude/flight level.

**Automatic altitude-keeping device.** Any equipment which is designed to automatically control the aircraft to a referenced pressure-altitude.

**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.

**Flight technical error (FTE).** The difference between the altitude indicated by the altimeter display being used to control the aircraft and the assigned altitude/flight level.

**Height-keeping capability.** The aircraft height-keeping performance that 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.

**Non-compliant aircraft.** An aircraft configured to comply with the requirements of an RVSM MASPS which, through height monitoring, is found to have a total vertical error (TVE) or an assigned altitude deviation (AAD) of 90 m (300 ft) or greater or an altimetry system error (ASE) of 75 m (245 ft) or more.

**Operational error.** Any vertical deviation of an aircraft from the correct flight level as a result of incorrect action by air traffic control (ATC) or the aircraft crew.

**Overall risk.** The risk of collision due to all causes, which includes the technical risk (see definition) and all risk due to operational errors and in-flight contingencies.

**RVSM approval.** The term used to describe the successful completion of airworthiness requirements and operational approval (if required).

**Target level of safety (TLS).** A generic term representing the level of risk which is considered acceptable in particular circumstances.

**Technical risk.** The risk of collision associated with aircraft height-keeping performance.

**Total vertical error (TVE).** The vertical geometric difference between the actual pressure altitude flown by an aircraft and its assigned pressure altitude (flight level).

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

**Vertical separation minimum (VSM).** VSM is documented in the Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444) as being a nominal 300 m (1 000 ft) below FL 290 and 600 m (2 000 ft) above FL 290 except where, on the basis of regional agreement, a value of less than 600 m (2 000 ft) but not less than 300 m (1 000 ft) is prescribed for use by aircraft operating above FL 290 within designated portions of the airspace.

## 4.2 Acronyms and Abbreviations

AAD	assigned altitude deviation
ACAS	airborne collision avoidance system
ACC	area control centre
ADS-B	automatic dependent surveillance–broadcast
ASE	altimetry system error
ATC	air traffic control
ATS	air traffic services

CFL	cleared flight level
FAA	Federal Aviation Administration
FL	flight level
FTE	flight technical error
GMS	GPS-based monitoring system
GMU	GPS-based monitoring unit
GPS	global positioning system
HMU	height-monitoring unit
JAA	Joint Aviation Authority
MASPS	minimum aircraft system performance specification
MNPS	minimum navigation performance specification
NAT	North Atlantic
RMA	regional monitoring agency
RVSM	reduced vertical separation minimum
SMS	safety management system
SSE	static source error
SSR	secondary surveillance radar
TLS	target level of safety
TVE	total vertical error
VSM	vertical separation minimum

## **5.0 AIRWORTHINESS APPROVAL**

### **5.1 RVSM MASPS**

Airworthiness approval must in all cases be in accordance with the requirements of the RVSM MASPS. As stated in ICAO Doc 9574 Chapter 3, the RVSM MASPS, in addition to characterizing the ASE and automatic height-keeping capability requirements, also contains specifications and procedures for type approval and continued airworthiness.

All approvals will be applicable to an individual aircraft or to a group of aircraft, that are nominally identical in aerodynamic design and items of equipment contributing to height-keeping accuracy.

### **5.2 Definition of aircraft type groupings**

For aircraft to be considered as part of a group for the purposes of airworthiness approval, the following conditions should be satisfied:

- a) the aircraft should have been constructed to a nominally identical design and should be approved on the same Type Certificate (TC), TC amendment, or Supplemental TC, as applicable;
- b) the static system of each aircraft should be nominally identical. The static source error (SSE) corrections should be the same for all aircraft of the group; and
- c) the avionics units installed on each aircraft to meet the minimum RVSM equipment criteria should comply with the manufacturer's same specification and have the same part number.

*Note: Aircraft that have avionics units which are of a different manufacturer or part number may be considered part of the group if it can be demonstrated that this standard of avionics equipment provides equivalent system performance.*

If an airframe does not meet the above conditions to qualify as a part of a group, and is presented as an individual airframe for approval, it will be considered to be a non-group aircraft. The significance of this is that the certification processes for group and non-group aircraft are different.

### **5.3 Continued airworthiness**

5.5 It is imperative that all aircraft continue, during their service life, to satisfy the requirements of the RVSM MASPS. While height-monitoring data from independent sources, as recommended by ICAO, should help to detect any long-term deterioration in altimetry system performance, it is nevertheless essential that certifying authorities ensure that, as part of the approval process, operator maintenance and inspection practices are reviewed and updated to reflect the specific airworthiness requirements applicable to RVSM operations.

### **5.4 Responsibilities**

Operators will ensure they submit aircraft, maintenance programmes together with the RVSM operations documentation to enable the Authority's issuance of OpSpecs authorizing the operator to conduct flight in RVSM airspace.

The operator shall submit the RVSM application and all aircraft eligibility documents, evidence of capability of operating and an RVSM maintenance programme for maintaining each aircraft or aircraft group to which the application relates for approval.

## 5.5 Aircraft Compliance

An aircraft may be authorized to conduct RVSM operations if the Authority finds that it complies with the RVSM requirements as set out in this AC. The operator shall ensure all relevant Service Bulletins (SB), Service Letters (SL), or Supplemental Type Certificates (STC), which apply to the specific aircraft type or group as applicable have been complied with.

Aircraft compliance review - the operator shall be required to demonstrate the following through the aircraft's RVSM documentation:

- (a) **In-Service Aircraft.** inspections and/or modifications required for aircraft compliance have been performed and documented;
- (b) **Equipment.** the aircraft has the required equipment in accordance with Reg. 17 of the Civil Aviation (Instruments and Equipment) Regulations.
- (c) **In-Production or New Production Aircraft.** RVSM compliance is stated in the aircraft flight manual (AFM) or aircraft Type Certificate Data Sheet (TCDS).

3.3.3 The RVSM compliant aircraft equipment shall include at least the following:

- (i) Two independent altitude measurement systems. Each system should include:
  - a) Cross-coupled static source/system, with ice protection if located in areas subject to ice accretion.
  - b) Equipment for measuring static pressure sensed by static source, conveying it to pressure altitude and displaying the pressure altitude to the flight crew.
  - c) Equipment for providing a digitally encoded signal corresponding to the displayed pressure altitude, for automatic altitude reporting purposes.
  - d) Static source error correction (SSES).
  - e) Signals referenced to a pilot selected altitude for automatic control and alerting.
- (ii) One secondary surveillance radar transponder with an altitude reporting System that can be connected to the altitude measurement system in use for altitude keeping.
- (iii) An altitude alerting system.
- (iv) An automatic altitude control system.

## 5.6 RVSM Maintenance Programme

The RVSM maintenance programme shall outline procedures to maintain aircraft in accordance with the requirements. The approved RVSM maintenance programme may be a stand-alone or part of the standard aircraft maintenance programme.

RVSM maintenance programme elements should be specific to the operator and aircraft for which they are approved and are not transferable.

Each RVSM maintenance programme shall include the following:

- (a) Identification of components considered to be RVSM critical, and identification of structural areas noted as RVSM critical areas;
- (b) The name or title of the responsible person who will ensure that the aircraft is maintained in accordance with the approved programme;
- (c) The method the operator will use to ensure that all personnel performing maintenance on the RVSM system are properly trained, qualified, and knowledgeable of that specific system;
- (d) The method the operator will use to notify the crew if the aircraft has been restricted from RVSM but is airworthy for an intended flight;
- (e) The method the operator will use to ensure conformance to the RVSM maintenance standards, including the use of calibrated and appropriate test equipment and a quality assurance programme for ensuring continuing accuracy and reliability of test equipment, especially when outsourced;
- (f) The method the operator will use to verify that components and parts are eligible for installation in the RVSM system, as well as to prevent ineligible components or parts from being installed;
- (g) The method the operator will use to return an aircraft to service after maintenance has been performed on an RVSM component/system or after the aircraft was determined to be non-compliant;
- (h) Periodic inspections, functional flight tests, and maintenance and inspection procedures with acceptable maintenance practices for ensuring continued compliance with the RVSM aircraft requirements;

*Note 1: These elements may be listed in detail or described by reference to an acceptable programme that is identified and controlled by revision or issue number.*

*Note 2: The need for functional flight tests may be limited to only after repairs or modifications that are deemed to warrant such testing and may be accomplished through monitoring height-keeping performance*

- (i) The maintenance requirements listed in Instructions for Continued Airworthiness (ICA) associated with any RVSM associated component or modification;
- (j) Any other maintenance requirement that needs to be incorporated to ensure continued compliance with RVSM requirements.

## **6.0 OPERATIONAL APPROVAL**

6.1 Where RVSM is applied, the specific aircraft type or types that the operator intends to use will need to be approved by the Authority. RVSM approval will encompass the following elements:

a) *Airworthiness approval (including continued airworthiness) process.* The aircraft will be approved as meeting the requirements of the appropriate State airworthiness document derived from the height-keeping capability requirements as defined by the airworthiness certification requirements. Furthermore, the aircraft altimetry and height-keeping equipment must be maintained in accordance with approved procedures and servicing schedules; and

b) *Operational approval process.* In addition to the airworthiness process described above an operator is required to meet Operational Approval requirements to be allowed to operate in RVSM airspace. Achievement of operational approval requirements will culminate in issuance of RVSM approval in the applicable aircraft type Operations Specifications

### **6.2 Validity of approval**

RVSM approval issued for one region (or state) will always be valid for RVSM operations in another region (or state) provided specific restrictions have not been imposed on the operator by the State of the Operator or State of Registry.

### **6.3 Confirmation of approval status**

Continuity of RVSM operations is dependent on the establishment of an aircraft approval confirmation process by the Authority, which is intended to exclude unqualified aircraft and operators from operating in RVSM airspace unless the appropriate separation is applied.

A secondary responsibility rests with the air traffic services (ATS) provider States to institute routine checks of the approval status of aircraft operating within their area of authority and intending to operate in RVSM airspace.

Depending on State regulations, ATC clearances may be withheld for operations that are not in compliance with the airspace requirements.

In conjunction with the ATS provider, a further level of confirmation of approval can be affected by the Regional Monitoring Agency (RMA) of a region in which RVSM applies. This can be achieved by the RMA taking action, following a query by a controlling authority, to obtain confirmation of approval status from the State of the Operator/State of Registry of aircraft which are not listed in an RVSM-approvals database.

## **7.0 PROCEDURES**

### **7.1 Cruising levels**

The table of cruising levels specified in Appendix 3 of Annex 2 to the Convention on International Civil Aviation, for use in RVSM airspace, shall be used.

### **7.2 Flight Crew Operating Procedures**

#### *In-flight procedures*

2.1 Generally, flight crew operating procedures in RVSM airspace are no different from those in any other airspace; however, the continuity of RVSM operations will require periodic review of procedures specific to a region, e.g. contingency procedures, and should be reflected in regional documentation.

Given the safety requirements and the effect large height deviations could have on the risk levels, crews should be reminded to exercise vigilance to minimize the occurrence of deviations from the cleared flight level. To this end, during routine training, flight crews should be reminded of the importance of adhering to the following in-flight procedures:

a) in level cruise it is essential that the aircraft be flown at the cleared flight level (CFL). This requires that particular care be taken to ensure that ATC clearances are fully understood and complied with. Except in the event of an emergency, the aircraft should not intentionally depart from CFL without a clearance from ATC;

b) during cleared transition between levels, the aircraft should not be allowed to overshoot or undershoot the new flight level by more than 45 m (150 ft);

*Note: The transition should be accomplished using the altitude capture feature of the automatic altitude-keeping device, if installed.*

c) an automatic altitude-keeping device should be operative and engaged during level cruise, except when circumstances such as turbulence or the need to re-trim the aircraft require its disengagement.

In any event, adherence to cruise altitude should be done by reference to one of the two altimeters required by the RVSM MASPS;

d) the altitude-alerting device should be operating and engaged;

e) regular (hourly) cross-checks between the altimeters should be made, and a minimum of two RVSM compliant systems must agree within 60 m (200 ft). Failure to meet this condition will require that the system be reported as defective and notified to ATC;

f) the operating altitude-reporting transponder should be connected to the RVSM MASPS-compliant altimetry system being used to control the aircraft;

g) before entering RVSM airspace, the pilot should review the status of equipment required. The following equipment should be operating normally:

- i. two altitude measurement systems, as defined by the RVSM aircraft systems specifications;
- ii. automatic altitude-keeping device(s);
- iii. at least one altitude-reporting transponder (if required for operation in that specific RVSM airspace) capable of being switched to operate from either of the two altimetry systems required by the RVSM aircraft systems specifications; and
- iv. one altitude-alerting device;

Should any of this equipment fail prior to the aircraft entering RVSM airspace, the pilot should request a new clearance so as to avoid flight in this airspace;

h) the following contingency procedures should be adhered to after entering RVSM airspace:

- i. the pilot should notify ATC of contingencies (equipment failures, weather conditions) in which the ability to maintain CFL is affected and coordinate a plan of action ;

- ii. equipment failures should be notified to ATC. Some examples are:
  - failure of all automatic altitude-keeping devices on board the aircraft;
  - ii) loss of redundancy of altimetry systems, or any part of these, on board the aircraft;
  - iii) failure of all altitude-reporting transponders;
  - iv) loss of thrust on an engine necessitating descent; and
  - v) any other equipment failure affecting the ability to maintain CFL;
- iii. the pilot should notify ATC when encountering severe turbulence; and
- iv. if unable to notify ATC and obtain an ATC clearance prior to deviating from the assigned CFL, the pilot should follow established contingency procedures as defined by the region of operation and obtain ATC clearance as soon as possible.

### **7.3 Operations manual**

Where applicable, aircraft operators should revise their operations manuals to reflect any differences in standard operating procedures that result from operation in RVSM airspace.

### **7.4 ATC Procedures**

#### **7.4.1 General**

3.1 The continuity of RVSM operations safely in relation to the provision of air navigation services requires that ATC procedures be periodically reviewed and appropriate recurrent training provided. As a basis for the periodic review of regional procedures, consideration should be given to the appropriate action to be taken by controllers in the following situations, as applicable:

- a) aircraft known not to be suitably equipped are flight planned into RVSM airspace;
- b) an aircraft informs ATC that the capability to maintain a CFL appropriate to RVSM requirements has been lost;
- c) the pilot advises that the automatic altitude-keeping device has been turned off; and
- d) the displayed altitude differs from the CFL by 90 m (300 ft) or more.

*Note 1: While not necessary to support RVSM operations, the availability of altitude display is beneficial.*

*Note 2: Surveillance systems should be capable of supporting RVSM operations.*

#### **7.4.2 ATC contingency procedures**

In addition to emergency conditions that require immediate descent, such as loss of thrust or pressurization, ATC shall be made aware of any conditions that may make it impossible for an aircraft to maintain its CFL. Controllers should be trained regarding the appropriate action to take in the event that they are notified by the pilot of any such condition, as described above. Suggested actions in the event of such an occurrence are:

- a) obtain the pilot's intentions;

- b) assess the traffic situation to determine if the aircraft can be accommodated through the provision of lateral, longitudinal or increased vertical separation and, if so, apply the appropriate minimum;
- c) when the aircraft cannot be accommodated in accordance with b), ascertain if the aircraft can maintain altitude in accordance with the requirements applicable below RVSM airspace. If so, and if the pilot confirms it to be operationally feasible, the controller should issue a revised clearance to a level outside RVSM airspace when traffic permits; and
- d) handle aircraft that cannot be accommodated in accordance with either b) or c) as an emergency and take whatever action is necessary to provide the appropriate separation.

#### **7.4.2 RVSM Phraseology**

Flight crew should report RVSM approved status with **'Affirm RVSM'** and report RVSM non-approved with **'Negative RVSM'** followed by reason.

Flight crew denying ATC clearance into RVSM should state **'Unable RVSM'** followed by the reason, for example **'Unable RVSM due turbulence'** or **'Unable RVSM due equipment'**.

Flight crew able to resume RVSM should use the phrase **'Ready to resume RVSM'**.

ATC should be informed when a non-RVSM approved State aircraft is requesting climb into RVSM airspace thus **'...Request FL330, Negative RVSM'**.

If able, ATC will give the clearance as follows **'...Climb to FL 330, Negative RVSM'**. Notice that the term 'Negative RVSM' is used in the clearance and the read-back, thus 'Climb to FL 320, Negative RVSM...'. Otherwise ATC will state that they are unable to issue the clearance into RVSM airspace.

### **7.5 Meteorological conditions**

7.5.1 Meteorological conditions that can cause turbulence which can be detrimental to accurate height-keeping include:

- a) gravity shear waves;
- b) thunderstorms;
- c) orographic flow.

7.5.2 Orographic flow, more commonly known as mountain wave activity, has been identified as being particularly detrimental to accurate height-keeping. Prior to implementation of RVSM, States known to have airspace susceptible to orographic flow should:

- a) assign responsibility for forecasting such conditions; and
- b) detail the action required by ATC on receipt of such forecasts.

7.5.3 When reports of severe turbulence are received, ATC must ascertain the capability of the aircraft to maintain CFL. Upon confirmation that meteorological conditions are affecting, or are likely to affect, height-keeping accuracy, ATC should be required to provide alternative separation as soon

as possible. Additionally, when any significant meteorological conditions are expected to prevail over an area for an extended time period, the appropriate ATC authority should consider:

- a) issuing a NOTAM specifying the routes or area affected; and
- b) temporarily suspending the use of 300 m (1 000 ft) VSM in the affected area.

### **Application Documentation**

The operator should submit an application letter with completed FORM: KCAA/FOPS/RVSM/001. This should be accompanied by an application package of relevant documents and revisions including the following:

- a) Airworthiness documents - Documentation that shows that the aircraft has RVSM airworthiness approval. This should include an aircraft flight manual (AFM) amendment or supplement;
- b) Description of aircraft equipment - A description of the aircraft appropriate to operations in an RVSM environment;
- c) Training programmes, operating practices and procedures - The operator should submit training syllabi for initial and recurrent training programmes together with other relevant material. The material should show that the operating practices, procedures and training items, related to RVSM operations in airspace that requires State operational approval, are incorporated;
- d) Procedure Manuals - The appropriate manuals (and checklists as applicable) should be revised to include information/guidance on standard operating procedures. Manual references should include any RVSM operating limitations or conditions established for that aircraft type. Manuals and checklists may need to be re-submitted for review by the competent authority as part of the application process;
- e) Past performance - Relevant height-keeping performance history, where available, should be included in the application. This should include any required changes that have been made in training, operating or maintenance practices to improve height keeping;
- f) Minimum equipment list (MEL) - A minimum equipment list (MEL), adapted from the master minimum equipment list (MMEL), should include items pertinent to operating in RVSM airspace;
- g) Participation in height keeping monitoring programmes. The operator should establish a plan for participation in an RVSM monitoring programme acceptable to the competent authority. This plan should include, as a minimum, a check on a sample of the operator's fleet by the AFI regional monitoring agency (ARMA)'s independent height-monitoring system; and
- h) Continuing airworthiness - Aircraft maintenance programme and continuing airworthiness procedures in support of the RVSM operations.



**Kenya Civil Aviation Authority**