



GENERAL

ADVISORY

CIRCULAR

CIVIL AVIATION AUTHORITY OF BOTSWANA

CAAB Document GAC-006 Rev. 01

REDUCED VERTICAL SEPARATION MINIMA (RVSM) APPROVAL

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1. POLICY AND GENERAL INFORMATION

1.1 PURPOSE

This General Advisory Circular (GAC-006) provides guidance for obtaining approval to operate aircraft in Reduced Vertical Separation Minima (RVSM) airspace.

1.2 STATUS OF THIS ADVISORY CIRCULAR

This General Advisory Circular (GAC-006) Revision 01 becomes effective immediately. It supersedes the original version issued 04 October 2012.

1.3 BACKGROUND

1.3.1 For flights in defined portions of airspace where, based on Regional Air Navigation Agreement, a reduced vertical separation minimum (RVSM) of 300 m (1 000 ft) is applied between FL 290 and FL 410 inclusive, an aeroplane:

- (a) shall be provided with equipment which is capable of:
 - (i) indicating to the flight crew the flight level being flown;
 - (ii) automatically maintaining a selected flight level;
 - (iii) providing an alert to the flight crew when a deviation occurs from the selected flight level. The threshold for the alert shall not exceed ± 90 m (300 ft); and,
 - (iv) automatically reporting pressure-altitude; and
- (b) shall be authorized by the State of the Operator for operation in the airspace concerned.

1.3.2 Prior to granting the RVSM approval required in paragraph 1.3.1 (b), the Civil Aviation Authority of Botswana (CAAB) shall be satisfied that:

- (i) the vertical navigation performance capability of the aeroplane satisfies the requirements specified in the Civil Aviation (Equipment and Instruments) Regulations, 2012 and this General Advisory Circular;
- (ii) the operator has instituted appropriate procedures in respect of continued airworthiness (maintenance and repair) practices and programmes; and
- (iii) the operator has instituted appropriate flight crew procedures for operations in RVSM airspace.

1.3.3 An RVSM approval is valid globally on the understanding that any operating procedures specific to a given region will be stated in the operations manual or appropriate crew guidance.

1.4 APPLICABILITY

The requirement for obtaining RVSM approval is applicable to any aircraft or operator registered with the CAAB seeking to operate or conduct flight in RVSM airspace.

Advisory Circulars (ACs) are intended to provide advice and guidance to illustrate an acceptable means, but not necessarily the only means, of complying with the regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material. Where a regulation contains the words "prescribed by the Authority," the AC may be considered to prescribe a viable method of compliance, but status of that "prescription" is always "guidance" (never regulation).

1.5 RELATED REGULATIONS

- Regulations 18 and 16.(2) of the Civil Aviation (Equipment and Instruments) Regulations, 2012.

1.6 RELATED PUBLICATIONS

- Joint Aviation Authority (JAA) Temporary Guidance Leaflet (TGL) No. 6
- FAA Document 91-RVSM
- ICAO Doc 9536 – Review of the General Concept of Separation (RGCSP)
- ICAO Doc 9574 – Manual on the Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive.

1.7 DEFINITIONS & ACRONYMS

1.7.1 The following definitions are used in this advisory circular –

Aircraft Group A group of aircraft that are of nominally identical design and build with respect to all details that could influence the accuracy of height keeping performance.

Altimetry System Error (ASE) The difference between the pressure altitude displayed to the flight crew when referenced to the International Standard Atmosphere ground pressure setting (1013.2 hPa /29.92 in.Hg) and free stream pressure altitude.

Assigned Altitude Deviation (AAD) The difference between the transmitted Mode C altitude and the assigned altitude/ flight level.

Authority The Civil Aviation Authority of Botswana (CAAB) or where applicable, the responsible authority of the State of Operator/Design/Manufacture.

Automatic Altitude Control System Any system that is designed to automatically control the aircraft to a referenced pressure altitude.

Avionics Error (AVE) The error in the processes of converting the sensed pressure into an electrical output, of applying any static source error correction (SSEC) as appropriate, and of displaying the corresponding altitude.

Basic RVSM Envelope The range of Mach numbers and gross weights within the altitude ranges FL 290 to FL 410 (or maximum attainable altitude) where an aircraft can reasonably expect to operate most frequently.

Full RVSM Envelope The entire range of operational Mach numbers, W/δ , and altitude values over which the aircraft can be operated within RVSM airspace.

General Air Traffic (GAT) Flights conducted in accordance with the rules and provisions of ICAO.

Height keeping Capability 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 a flight level.

Non-Group Aircraft An aircraft for which the operator applies for approval on the characteristics of the unique airframe rather than on a group basis.

Operational Air Traffic (OAT) Flights which do not comply with the provisions stated for GAT and for which rules and procedures have been specified by appropriate authorities.

RVSM Approval The approval that is issued by the appropriate authority of the State in which the Operator is registered.

Residual Static Source Error The amount by which static source error (SSE) remains undercorrected or overcorrected after the application of SSEC.

State Aircraft Aircraft used in military, customs and police services shall be deemed to be State aircraft.

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 for static source error.

Total Vertical Error (TVE) Vertical geometric difference between the actual pressure altitude flown by an aircraft and its assigned pressure altitude (flight level).

W/δ Aircraft weight, W, divided by the atmospheric pressure ratio, δ.

1.7.2 The following acronyms are used in this advisory circular -

AAD	Assigned Altitude Deviation
AFI	Africa-Indian Ocean Region
AFM	Aircraft Flight Manual
AOC	Air Operator's Certificate
ARMA	AFI Regional Monitoring Agency
ASE	Altimetry System Error
CARs	Botswana Civil Aviation Regulations
FSD	Flight Safety Directorate of the Civil Aviation Authority of Botswana.
ICAO	International Civil Aviation Organization
MASPS	Minimum Aircraft System Performance Specifications
MMEL	Master Minimum Equipment List
RMA	Regional Monitoring Agency
RVSM	Reduced vertical Separation Minimum
SB	Service Bulletin
SSEC	Static Source Error Correction
SSR	Secondary Surveillance Radar
TVE	Total Vertical Error

2. GENERAL POLICY

- 2.1 Any aircraft or operator registered with Civil Aviation Authority of Botswana (CAAB) seeking to operate or conduct flight in airspace or routes where Reduced Vertical Separation Minima (RVSM) is applied must first seek approval from CAAB.
- 2.2 An application for RVSM approval should be made in **CAAB Form RVSM-01** and submitted to the CAAB together with all required documents. RVSM approval has two (2) aspects: *Airworthiness approval* and *Operational approval*, both of which will be addressed in the application.
- 2.3 Approval granted by Airworthiness – Flight Safety Directorate must in all cases be against the requirements of the Minimum Aircraft System Performance Specifications (MASPS). The MASPS will comprise specifications and procedures for the separate aspects of type approval, release from production, and continued airworthiness.
- 2.4 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.
- 2.5 The approval cannot be transferred from one owner to the other.
- 2.6 Validity of the approval will depend on the aircraft and operator maintaining the equipment on the aircraft in a serviceable state as well as ensuring adequacy of training programmes and operating practices and procedures of flight crew.
- 2.7 Aircraft to be registered in Botswana holding valid RVSM approvals that are in compliance with EASA (JAA Information Leaflet No. 6) or FAA (interim Guidelines 91-RVSM), will be granted CAAB approval on the weight of their existing approvals to continue operation under RVSM.

3. THE APPROVAL PROCESS

3.1 General

Airspace where RVSM is applied should be considered special qualification airspace. The specific aircraft type or types that the operator intends to use will need to be approved by the Authority before the operator conducts flight in RVSM airspace. In addition, where operations in specified airspace require approval in accordance with an ICAO Regional Navigation Agreement, an operational approval will be needed. This Advisory Circular provides guidance for the approval of specific aircraft type or types, and for operational approval.

3.2 Approval of Aircraft: Airworthiness approval

- 3.2.1 Each aircraft type that an operator intends to use in RVSM airspace should have received RVSM airworthiness approval from the Authority in accordance with paragraph 6 prior to approval being granted for RVSM operations. Paragraph 7 contains guidance on the continued airworthiness (maintenance and repair) programmes for all RVSM operations.

NOTE: Operators are advised to check existing approvals and the Aircraft Flight Manual for redundant regional constraints

3.3 Operational Approval

For certain airspace, as defined by ICAO Regional Navigation Agreements, operators are required to hold State approval in order to operate in that airspace, which may or may not include RVSM. Paragraph 8 contains guidance on operational procedures that an operator may need to adopt for such airspace where RVSM is applied including

advice on the operational material that may need to be submitted for review by the Authority.

4. RVSM PERFORMANCE

4.1 General

The objectives set out by the ICAO Document 9536 – *Review of the General Concept of Separation (RGCSP)*, have been translated into airworthiness standards by assessment of the characteristics of altimetry system error (ASE) and automatic altitude control.

4.2 RVSM Flight Envelopes

For the purposes of RVSM approval, the aircraft flight envelope may be considered as two parts; the Basic RVSM flight planning envelope and the Full RVSM flight envelope (referred to as the Basic envelope and the Full envelope respectively), as defined in paragraph 1.7 and explained in 6.4. For the full envelope, a larger ASE is allowed.

4.3 Altimetry System Error

4.3.1 To evaluate a system against the ASE performance statements established by RGCSP, it is necessary to quantify the mean and three standard deviation values for ASE, expressed as ASE_{mean} and ASE_{3SD} . To do this, it is necessary to take into account the different ways in which variations in ASE can arise. The factors that affect ASE are:

- (a) Unit to unit variability of avionics equipment.
- (b) Effect of environmental operating conditions on avionics equipment.
- (c) Airframe to airframe variability of static source error.
- (d) Effect of flight operating conditions on static source error.

4.3.2 Assessment of ASE, whether based on measured or predicted data will need to consider sub-paragraphs (a) to (d) of 4.3.1. The effect of item (d) as a variable can be eliminated by evaluating ASE at the most adverse flight condition in an RVSM flight envelope.

4.3.3 The criteria to be met for the Basic envelope are:

- (a) At the point in the envelope where the mean ASE reaches its largest absolute value that value should not exceed 25 m (80 ft).
- (b) At the point in the envelope where absolute mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 60 m (200 ft).

4.3.4 The criteria to be met for the Full envelope are:

- (a) At the worst point in the Full envelope where the mean ASE reaches its largest absolute value, the absolute value should not exceed 37 m (120 ft).
- (b) At the point in the Full envelope where the mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 75 m (245 ft).
- (c) If necessary, for the purpose of achieving RVSM approval for a group of aircraft, an operating limitation may be established to restrict aircraft from

conducting RVSM operations in parts of the Full envelope where the absolute value of mean ASE plus three standard deviations of data submitted to support the approval application, and documented in appropriate aircraft operating manuals. However, visual or aural warning/indication associated with such limitation need not be provided in the aircraft.

4.3.5 Aircraft types for which an application for a Type Certificate is made after 1 January 1997, should meet the criteria established for the Basic envelope and Full RVSM envelope.

4.3.6 The standard for aircraft submitted for approval as non-group aircraft, as defined in sub-paragraph 6.3.2, is as follows:

(a) For all conditions in the Basic envelope:

- | Residual static source error + worst case avionics | ≤ 50 m (160 ft)

(b) For all conditions in the Full envelope:

- | Residual static source error + worst case avionics | ≤ 60 m (200 ft)

NOTE: *Worst case avionics means that a combination of tolerance values, specified by the aircraft manufacturer for the altimetry fit into the aircraft, which gives the largest combined absolute value for residual SSE plus avionics errors.*

4.4 Altitude Keeping

An automatic altitude control system is required capable of controlling altitude within +/- 20 m (+/- 65 ft) about the selected altitude, when the aircraft is operated in straight and level flight under non-turbulent, non-gust conditions.

NOTE: *Automatic altitude control systems with flight management system/performance management system inputs allowing variations up to +/- 40 m (130 ft) under non-turbulent, non-gust condition, installed in aircraft types for which an application for Type Certificate was made prior to January 1, 1997, need not be replaced or modified.*

5. AIRCRAFT SYSTEMS

5.1 Equipment for RVSM Operations

The list below outlines the minimum equipment fit for aircraft seeking airworthiness approval for RVSM operation:

5.1.1 Two independent altitude measurement systems. Each system will need to be composed of the following elements:

- (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 the static source, converting it to pressure altitude and displaying the pressure altitude to the flight crew;
- (c) Equipment for providing a digitally coded signal corresponding to the displayed pressure altitude, for automatic altitude reporting purposes;
- (d) Static source error correction (SSEC), if needed to meet the performance criteria of paragraphs 4.3.3, 4.3.4 or 4.3.6, as appropriate;

- (e) Signals referenced to a pilot selected altitude for automatic control and alerting. These signals should be derived from an altitude measurement system meeting the criteria of this document, and, in all cases, enabling the criteria relating to Altitude Control Output (paragraph 5.2.6) and Altitude Alerting (paragraph 5.3) to be met.

5.1.2 One Secondary Surveillance Radar (SSR) transponder with an altitude reporting system that can be connected to the altitude measurement system in use for altitude keeping.

5.1.3 An altitude alerting system

5.1.4 An automatic altitude control system

5.2 **Altimetry:**

5.2.1 **System Composition.** The altimetry system of an aircraft comprises all those elements involved in the process of sampling free stream static pressure and converting it to a pressure altitude output. The elements of the altimetry system fall into two main groups:

- (a) Airframe plus static sources.
- (b) Avionics equipment and/or instruments.

5.2.2 **Altimetry System Outputs.** The following altimetry system outputs are significant for RVSM operations:

- (a) Pressure altitude (Baro-corrected) for display.
- (b) Pressure altitude reporting data.
- (c) Pressure altitude or pressure altitude deviation for an automatic altitude control device.

5.2.3 **Altimetry System Accuracy.** The total system accuracy will need to satisfy the criteria of sub-paragraphs 4.3.3, 4.3.4 or 4.3.6 as appropriate.

5.2.4 **Static Source Error Correction (SSEC).** If the design and characteristics of the aircraft and its altimetry system are such that the criteria of sub-paragraphs 4.3.3, 4.3.4 or 4.3.6 are not satisfied by the location and geometry of the static sources alone, then the SSEC will need to be applied automatically within the avionics equipment of the altimetry system. The design aim for the static source error correction, whether applied by aerodynamic/geometric means or within the avionics equipment, should be to produce a residual static source error, but in all cases it should lead to compliance with the criteria of sub-paragraphs 4.3.3, 4.3.4 or 4.3.6 as appropriate.

5.2.5 **Altitude Reporting Capability.** The aircraft altimetry system will need to provide an output to the aircraft transponder as required by the applicable operating regulations.

5.2.6 **Altitude Control Output**

- (a) The altimetry system will need to provide a signal that can be used by an automatic altitude control system to control the aircraft to a selected altitude. The signal may be used either directly, or combined with other sensor signals. If SSEC is necessary to satisfy the criteria of sub-paragraph 4.3.3, 4.3.4 or 4.3.6 then an equivalent SSEC may be applied to the altitude control signal. The signal may be an altitude deviation signal, relative to the selected altitude, or a suitable absolute altitude signal.

- (b) Whatever the system architecture and SSEC system, the difference between the signal output to the altitude control system and the altitude displayed to the flight crew will need to be kept to the minimum.

5.2.7 **Altimetry System Integrity.** The RVSM approval process will be to verify that the predicted rate of occurrence of the undetected failure of the altimetry system does not exceed 1×10^{-5} per flight hour. All failures and failure combinations whose occurrence would not be evident from cross cockpit checks, and which would lead to altitude measurement/display errors outside the specified limits, need to be assessed against this value. Other failures or failure combinations need not be considered.

5.3 Altitude Alerting

The altitude deviation system will need to signal an alert when the altitude displayed to the flight crew deviates from selected altitude more than a nominal threshold value. For aircraft for which an application for a Type Certificate is made before 1 January 1997, the nominal threshold value will need to be greater than ± 90 m (± 300 ft). For aircraft for which an application for a Type Certificate is made on or after 1 January 1997, the value will need to be greater than ± 60 m (± 200 ft). The overall equipment tolerance in implementing these nominal values will need to be not greater than ± 15 m (± 50 ft).

5.4 Automatic Altitude Control System

5.4.1 As a minimum, a single automatic altitude system with an altitude keeping performance complying with sub-paragraph 4.4 will need to be installed.

5.4.2 Where an altitude select/acquire function is provided, the altitude select/acquire control panel will need to be configured such that an error of no more than ± 8 m (± 25 ft) exists between the value selected by, and displayed to, the flight crew, and the corresponding output to the control system.

5.5 System Limitations

5.5.1 The Aircraft Flight Manual should include a statement of compliance against this document (or any equivalent guidance material) quoting the applicable Service Bulletin or build standard of aircraft. In addition the following statement should be included:-

“Airworthiness Approval alone does not authorise the flight into airspace for which an RVSM Operational Approval is required by an ICAO regional Navigation Agreement.”

5.5.2 Non-compliant aspects of the installed systems and any other limitations will need to be identified in the approved Aircraft Flight Manual amendment or supplement, and in the applicable and approved Operations Manual.

For example: -

- Non-compliant altimeter systems, e.g. standby altimeter;
- Non-compliant modes of the automatic pilot, e.g. altitude hold, Vnav, altitude select;
- Weight limit;
- Mach limit;
- Altitude limit.

6. AIRWORTHINESS APPROVAL

6.1 General

6.1.1 In order to operate an aircraft in RVSM airspace, the aircraft must either have been built to comply with RVSM requirements or alternatively it must be modified to comply with RVSM requirements.

6.1.2 Obtaining RVSM airworthiness approval is a two-step process which may involve more than one authority.

6.1.3 STEP 1:

A. In the case of a newly built aircraft, the aircraft manufacturer develops and submits to the Authority of the State of manufacturer, the performance and analytical data that supports RVSM airworthiness approval of a defined build standard. The data will be supplemented with maintenance and repair manuals giving associated continued airworthiness instructions. Compliance with RVSM criteria will be stated in the Aircraft Flight Manual including reference to the applicable build standard, related conditions and limitations. Approval by the Authority, and where applicable, validation of that approval by other Authorities, indicates acceptance of newly built aircraft conforming to that type and build standard as complying with the RVSM airworthiness criteria.

B. In the case of an aircraft already in service, the aircraft manufacturer (or an approved design organisation), submits to the Authority, either in the State of manufacture or the State of registry, the performance and analytical data that supports RVSM airworthiness approval of a defined build standard. The data will be supplemented with a Service Bulletin (SB), or its equivalent, that identifies the work to be done to achieve the build standard, continued airworthiness instructions, and an amendment to the Aircraft Flight Manual stating related conditions and limitations. Approvals by the Authority, and, where applicable, validation of that approval by other Authorities, indicates acceptance of that aircraft type and build standard as complying with RVSM airworthiness criteria.

6.1.4 The combination of performance and analytical data, SBs or equivalent, continued airworthiness instructions, and the approved amendment or supplement to the Aircraft Flight Manual forms part of the RVSM approval data package.

6.1.5 STEP 2:

For the second step, an aircraft operator may apply to the Authority using **CAAB Form RVSM-01**, for airworthiness approval of specific aircraft. The application will need to be supported by evidence confirming that the specific aircraft has been inspected and, where necessary, modified in accordance with applicable SBs, and is of a type and build standard that meets the RVSM airworthiness criteria. The operator will need to confirm also that the continued airworthiness instructions are available and that the approved Flight Manual amendment or supplement has been incorporated. Approval by CAAB indicates that the aircraft is eligible for RVSM operations. The authority will notify the designated monitoring cell accordingly.

An RVSM approval is valid globally on the understanding that any operating procedures specific to a given region will be stated in the operations manual or appropriate crew guidance.

6.2 Contents of RVSM Approval Data Package

6.2.1 As a minimum, the data package will need to consist of the following items:

(a) A statement of the aircraft group or non-group aircraft and applicable build standard to which the data package applies.

- (b) A definition of the applicable flight envelope(s).
- (c) Data showing compliance with the performance criteria of paragraphs 4 and 5.
- (d) The procedures to be used to ensure that all aircraft submitted for airworthiness approval comply with RVSM criteria. These procedures will include the reference of applicable SBs and the applicable approved AFM amendment or supplement.
- (e) The maintenance instructions that ensure continued airworthiness for RVSM approval.

6.2.2 The items listed in 6.2 are explained further in the following sub-paragraphs.

6.3 Aircraft Groupings

6.3.1 For aircraft to be considered as members of a group for the purposes of RVSM approval, the following conditions should be satisfied:

- (a) Aircraft should have been constructed to a nominally identical design and be approved on the same Type Certificate (TC), TC amendment, or Supplemental TC, as applicable.

NOTE: For derivative aircraft it may be possible to use the data from the parent configuration to minimize the amount of additional data required to show compliance. The extent of additional data required will depend on the nature of the difference.

- (b) The static system of each aircraft should be nominally identical. The SSE corrections should be the same for all aircraft of the group.
- (c) The avionics units installed on each aircraft to meet the minimum RVSM equipment criteria of sub-paragraph 5.1 should comply with the manufacturer's same specification and have the same part number.

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

6.3.2 If an airframe does not meet the conditions of sub-paragraphs 6.3.1(a) to (c) to qualify as a member of a group, or is presented as an individual airframe for approval, then it will need to be considered as a non-group aircraft for the purposes of RVSM approval.

6.4 Flight Envelopes

The RVSM operational flight envelope is the Mach number, W/δ , and altitude ranges over which an aircraft can be operated in cruising flight within the RVSM airspace. The RVSM operational flight envelope may be divided into two parts: *Full RVSM Flight Envelope* and *Basic Flight Envelope*, as defined in section 5 of this document.

6.5 Performance Data

The data package should contain data sufficient to show compliance with the accuracy criteria set by paragraph 4.

6.5.1 *General.* ASE will generally vary with flight condition. The data package should provide coverage of the RVSM envelope sufficient to define the largest errors in the Basic and Full envelopes. In the case of group aircraft approval, the worst flight condition may be different for each of the criterion of subparagraph 4.3.3 and 4.3.4. Each should be evaluated.

6.5.2 *Avionic Equipment*. Avionic equipment should be identified by function and part number. A demonstration will need to show that the avionic equipment can meet the criteria established by the error budget when the equipment is operated in the environmental conditions expected to be met during RVSM operations.

6.6 Continued Airworthiness

6.6.1 The following items should be reviewed and updated as applicable to RVSM:

- (a) The Structural Repair Manual with special attention to areas around each static source, angle of attack sensors, and doors if their rigging can affect airflow around the previously mentioned sensors.
- (b) The Master Minimum Equipment List (MMEL).

6.6.2 The data package should include details of any special procedures that are not covered in sub-paragraph 6.6.1, but may be needed to ensure continued compliance with RVSM approval criteria. Examples follow:

- (a) For non-group aircraft, where airworthiness approval has been based on flight test, the continuing integrity and accuracy of the altimetry system will need to be demonstrated by ground and flight tests of the aircraft and its altimetry system at periods to be agreed with the Authority. However, alleviation of the flight test requirement may be given if it can be demonstrated that the relationship between any subsequent airframe/system degradation and its effects on altimetry system accuracy is understood and that it can be compensated or corrected.
- (b) In-flight defect reporting procedures should be defined to aid identification of altimetry system error sources. Such procedures could cover acceptable differences between primary and alternate static sources, and others as appropriate.
- (c) For groups of aircraft where approval is based on geometric inspection, there may be a need for periodic re-inspection, and the interval required should be specified.

6.7 Post Approval Modification

Any variation/modification from the initial installation that affects RVSM approval should be referred to the aircraft manufacturer or approved design organisation, and accepted by the Authority.

7. CONTINUED AIRWORTHINESS (MAINTENANCE PROCEDURES)

7.1 General

- (a) The integrity of the design features necessary to ensure that altimetry systems continue to meet RVSM approval criteria should be verified by scheduled tests and inspections in conjunction with an approved maintenance programme. The operator should review its maintenance procedures and address all aspects of continued airworthiness that may be relevant.
- (b) Adequate maintenance facilities will need to be available to enable compliance with the RVSM maintenance procedures.

7.2 Maintenance Programmes

Each operator requesting RVSM operational approval should establish RVSM maintenance and inspection practices acceptable to, and as required by, the Authority, that include any required maintenance specified in the data package (sub-paragraph 6.2). Operators of aircraft subject to maintenance programme approval will need to incorporate these practices in their maintenance programme. *See Appendix 2 for additional information regarding RVSM maintenance Programme.*

7.3 Maintenance Documents

The following documents should be reviewed, as appropriate:

- (a) Maintenance Manuals.
- (b) Structural Repair Manuals.
- (c) Standard Practices Manual.
- (d) Illustrated Parts Catalogues.
- (e) Aircraft Maintenance Programme.
- (f) MMEL/MEL

7.4 Maintenance Practices

If the operator is subject to an approved maintenance programme, that programme should include, for each aircraft type, the maintenance practices stated in the applicable aircraft and component manufacturer's maintenance manuals. In addition, for all aircraft, including those not subject to an approved maintenance programme, attention should be given to the following items:

- (a) All RVSM equipment should be maintained in accordance with the component manufacturer's maintenance instructions and the performance criteria of the RVSM approval data package.
- (b) Any modification or design change which in any way affects the initial RVSM approval should be subject to a design review acceptable to the Authority.
- (c) Any repairs not covered by approved maintenance documents, that may affect the integrity of the continuing RVSM approval, (*e.g. those affecting the alignment of pitot/static probes, repairs to dents or deformation around static plates*), should be subject to a design review acceptable to the Authority.
- (d) Built-in Test Equipment (BITE) should not be used for system calibration unless it is shown to be acceptable by the aircraft manufacturer or an approved design organization, and with the agreement of the Authority.
- (e) An appropriate system leak check (or visual inspection where permitted) should be accomplished following reconnection of a quick disconnect static line.
- (f) Airframe and static systems should be maintained in accordance with the aircraft manufacturer's inspection standards and procedures.
- (g) To ensure the proper maintenance of airframe geometry for proper surface contours and the mitigation of altimetry system error, surface measurements or skin waviness checks will need to be made as specified by the aircraft manufacturer, to ensure adherence to RVSM tolerances. These checks should

be performed following repairs, or alterations having an effect on airframe surface and airflow.

- (h) The maintenance and inspection programme for the autopilot will need to ensure continued accuracy and integrity of the automatic altitude control system to meet the height keeping standards for RVSM operations. This requirement will typically be satisfied with equipment inspections and serviceability checks.
- (i) Whenever the performance of installed equipment has been demonstrated to be satisfactory for RVSM approval, the associated maintenance practices should be verified to be consistent with continued RVSM approval. Examples of equipment to be considered are:
 - (i) Altitude alerting.
 - (ii) Automatic altitude control system.
 - (iii) Secondary surveillance radar altitude reporting equipment.
 - (iv) Altimetry systems.

7.4.1 Action for Non-compliant Aircraft. Those aircraft positively identified as exhibiting height keeping performance errors that require investigation, as discussed in subparagraph 8.7, should not be operated in RVSM airspace until the following actions have been taken:

- (a) The failure or malfunction is confirmed and isolated; and,
- (b) Corrective action is taken as necessary and verified to support RVSM approval.

7.4.2 Maintenance Training. New training may be necessary to support RVSM approval. Areas that may need to be highlighted for initial and recurrent training of relevant personnel are:

- (a) Aircraft geometric inspection techniques.
- (b) Test equipment calibration and use of that equipment.
- (c) Any special instructions or procedures introduced for RVSM approval.

7.4.3 Test Equipment

- (a) The test equipment should have the capability to demonstrate continuing compliance with all the parameters established in the data package for RVSM approval or as approved by the Authority.
- (b) Test equipment should be calibrated at periodic intervals as agreed by the Authority using reference standards whose calibration is certified as being traceable to national standards acceptable to that Authority. The approved maintenance programme should include an effective quality control programme with attention to the following:
 - (i) Definition of required test equipment accuracy.
 - (ii) Regular calibrations of test equipment traceable to a master standard. Determination of the calibration interval should be a function of the stability of the test equipment. The calibration interval should be established using historical data so that degradation is small in relation to the required accuracy.

- (iii) Regular audits of calibration facilities both in-house and outside.
- (iv) Adherence to approved maintenance practices.
- (v) Procedures for controlling operator errors and unusual environmental conditions which may affect calibration accuracy.

8. OPERATIONAL APPROVAL

8.1 Purpose and Organisation

Paragraph 3 gives an overview of the RVSM approval processes. For airspace where operational approval is required, this paragraph describes steps to be followed and gives detailed guidance on the required operational practices and procedures. Appendix 1 is related to this paragraph and contains essential information for operational programmes.

8.2 RVSM operations

Approval will be required for each aircraft group and each aircraft to be used for RVSM operations. Approval will be required for each operator and the Authority will need to be satisfied that:

- (a) each aircraft holds airworthiness approval according to paragraph 6;
- (b) each operator has continued airworthiness programmes (maintenance procedures) according to paragraph 7;
- (c) where necessary, operating procedures unique to the airspace have been incorporated in operations manuals including any limitations identified in paragraph 5.5;
- (d) high levels of aircraft height keeping performance can be maintained.

8.3 Pre-Application Meeting

A pre-application meeting should be scheduled between the operator and the FSD. The intent of this meeting is to inform the operator of CAAB expectations in regard to approval to operate in an RVSM environment. The content of the operator RVSM application, CAAB review and evaluation of the application, demonstration flight requirements, and conditions for removal of RVSM approval should be basic items of discussion.

8.4 Content of Operator RVSM Application

The following material should be made available to the Authority for review and evaluation at least sixty (60) days before the intended start of RVSM operations:

- (a) *Airworthiness Documents.* Documentation that shows that the aircraft has RVSM approval. This should include an Approved Flight Manual amendment or supplement.
- (b) *Description of Aircraft Equipment.* A description of the aircraft equipment appropriate to operations in an RVSM environment.
- (c) *Training Programmes and Operating Practices and Procedures.* Holders of Air Operators Certificates (AOC) may need to submit training syllabi for initial, and where appropriate, recurrent training programmes together with other appropriate material to the Authority. The material will need to show that the operating practices, procedures and training items, related to RVSM operations in airspace that requires State operational approval, are incorporated. Non-AOC operators will need to comply with local procedures to satisfy the Authority that their knowledge of RVSM operating practices and procedures is equivalent to

that set for AOC Holders, sufficient to permit them to conduct RVSM operations. Guidance on the content of training programmes and operating practices and procedures is given in Appendix 1. In broad terms, this covers flight planning, pre-flight procedures, aircraft procedures before RVSM airspace entry, in-flight procedures, and flight crew training procedures.

- (d) *Operations Manuals and Checklists.* The appropriate manuals and checklists should be revised to include information/guidance on standard operating procedures as detailed in Appendix 1. Manuals should include a statement of the airspeeds, altitudes and weights considered in RVSM aircraft approval; including identification of any operating limitations or conditions established for that aircraft group. Manuals and checklists may need to be submitted for review by the authority as part of the application process.
- (e) *Past performance.* Relevant operating history, where available, should be included in the application. The applicant should show that changes needed in training, operating or maintenance practices to improve poor height keeping performance, have been made.
- (f) *Minimum Equipment List.* Where applicable, a minimum equipment list (MEL), adapted from the master minimum equipment list (MMEL) and relevant operational regulations, should include items pertinent to operating in RVSM airspace.
- (g) *Maintenance.* When application is made for operational approval, the operator should establish a maintenance programme acceptable to the Authority, as defined in paragraph 7.
- (h) *Plan for Participation in Verification/Monitoring Programmes.* The operator should establish a plan acceptable to the Authority, for participation in any applicable verification/monitoring programme (See 8.6). This plan will need to include, as a minimum, a check on a sample of the operator's fleet by an independent height monitoring system. (See paragraph 9 for additional guidance)

8.5 CAAB Review and Evaluation of Applications

8.5.1 Once the application has been submitted, the CAAB will begin the process of review and evaluation. If the content of the application is insufficient, the CAAB will request additional information from the operator.

8.5.2 When all the airworthiness and operational requirements of the application are met, the Authority will proceed with the approval process.

8.6 Demonstration Flight(s)

The content of the RVSM application may be sufficient to verify the aircraft performance and procedures. However, the final step of the approval process may require a demonstration flight. The Authority may appoint an inspector(s) for a flight in RVSM airspace to verify that all relevant procedures are applied effectively. If the performance is satisfactory, operational approval for RVSM airspace may be permitted.

8.7 Form of Approval Documents

8.7.1 Airworthiness Approval

An aircraft that has been found to comply with the requirements for operating in RVSM airspace will be issued with a certificate in the form of **CAAB Form AIR 270**. The certificate does not expire unless suspended or revoked.

8.7.2 Operational Approval

- (a) *Holders of an Air Operator's Certificate.* Approval to operate in designated RVSM airspace areas will be granted through issuance of operations specifications (opspecs) by the Authority in accordance with the Civil Aviation Regulations, or in compliance with national regulations where operational approval is required by an ICAO Regional Agreement. Each aircraft group for which the operator is granted approval will be listed in the Approval.
- (b) *Non AOC Holders.* These operators will be issued with an Approval as required by the Civil Aviation (Equipment and Instruments) Regulations, 2012 and this General Advisory Circular. This approval will be valid for a period of 2 years, and may require renewal.

NOTE: Subject to compliance with applicable criteria, an RVSM Approval combining the airworthiness approval of sub-paragraph 6.1.5 and the operational approval of paragraph 8.2 may be available from some authorities.

8.7.3 Copies of RVSM approvals should be carried in the aircraft at all times when operating in RVSM airspace.

8.8 **Airspace Monitoring**

For airspace where a numerical Target Level of Safety is prescribed, monitoring of aircraft height keeping performance in the airspace by an independent height monitoring system is necessary to verify that the prescribed level of safety is being achieved. However, an independent monitoring check of an aircraft is not a prerequisite for the grant of an RVSM approval.

8.9 **Suspension, Revocation and Reinstatement of RVSM Approval**

The incidence of height keeping errors that can be tolerated in an RVSM environment is small. It is expected of each operator to take immediate action to rectify the conditions that cause an error. The operator should report an occurrence involving poor height keeping to the Authority within 72 hours. The report should include an initial analysis of causal factors and measures taken to prevent repeat occurrences. The need for follow up reports will be determined by the Authority.

Occurrences that should be reported and investigated are errors of:

- (a) TVE equal to or greater than ± 90 m (± 300 ft),
- (b) ASE equal to or greater than ± 75 m (± 245 ft), and
- (c) Assigned altitude deviation equal to or greater than ± 90 m (± 300 ft).

8.9.1 *Height keeping Errors.* Height keeping errors fall into two broad categories:

- errors caused by malfunction of aircraft equipment; and
- operational errors.

8.9.2 An operator that consistently experiences errors in either category will have approval for RVSM operations suspended or revoked. If a problem is identified which is related to one specific aircraft type, then RVSM approval may be suspended or revoked for that specific type within that operator's fleet.

NOTE: The tolerable level of collision risk in the airspace would be exceeded if an operator consistently experienced errors.

8.9.3 *Operators Actions* The operator should make an effective, timely response to each height keeping error. The Authority may consider suspending or revoking RVSM approval if the operator's responses to height keeping errors are not effective or timely. The Authority will consider the operator's past performance record in determining the action to be taken.

8.9.4 *Reinstatement of Approval* The operator will need to satisfy the Authority that the causes of height keeping errors are understood and have been eliminated and that the operator's RVSM programmes and procedures are effective. At its discretion and to restore confidence, the Authority may require an independent height monitoring check of affected aircraft to be performed.

9. RVSM HEIGHT-KEEPING PERFORMANCE MONITORING

9.1 As mentioned in paragraph 8 of this advisory circular, the aircraft operator should participate in the RVSM monitoring programme. Thus, the operator should arrange for height-keeping performance monitoring with the regional RVSM monitoring agency (ARMA) or any other monitoring agency established in accordance with ICAO Annex 11.

9.2 RVSM height-keeping performance reports should be forwarded directly to the CAAB by the monitoring agency at least once a month or at intervals agreed upon by the Authority. The reports should be forwarded to:

Director, Air Navigation Services
Civil Aviation Authority of Botswana
P. O. Box 250
Gaborone
BOTSWANA

Reports may also be sent via e-mail to caab@caab.co.bw

9.3 Copies of the reports should also be forwarded to the Director, Flight Safety at the CAAB.

9.4 It is the duty of the aircraft operator to ensure that the CAAB is furnished with the RVSM height-keeping performance reports within the agreed timelines. Failure to do so may result in withdrawal of RVSM approval.


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For/Civil Aviation Authority of Botswana



Date: 17/12/2013

End of Advisory Circular

1. INTRODUCTION

Flight crews will need to have an awareness of the criteria for operating in RVSM airspace and be trained accordingly. The items detailed in paragraphs 2 to 6 of this appendix should be standardised and incorporated into training programmes and operating practices and procedures. Certain items may already be adequately standardised in existing procedures. New technology may also remove the need for certain actions required of the flight crew. If this is so, then the intent of this guidance can be considered to be met.

Note: This document is written for all users of RVSM airspace, and as such is designed to present all required actions. It is recognised that some material may not be necessary for larger public transport operators.

2. FLIGHT PLANNING

During flight planning the flight crew should pay particular attention to conditions that may affect operation in RVSM airspace. These include, but may not be limited to:

- (a) verifying that the airframe is approved for RVSM operations;
- (b) reported and forecast weather on the route of flight;
- (c) minimum equipment requirements pertaining to height keeping and alerting systems; and
- (d) any airframe or operating restriction related to RVSM approval.

3. PRE-FLIGHT PROCEDURES AT THE AIRCRAFT FOR EACH FLIGHT

The following actions should be accomplished during the pre-flight procedure:

- (a) review technical logs and forms to determine the condition of equipment required for flight in the RVSM airspace. Ensure that maintenance action has been taken to correct defects to required equipment;
- (b) during the external inspection of aircraft, particular attention should be paid to the condition of static sources and the condition of the fuselage skin near each static source and any other component that affects altimetry system accuracy. This check may be accomplished by a qualified and authorised person other than the pilot (e.g. a flight engineer or ground engineer);
- (c) before take-off, the aircraft altimeters should be set to the QNH of the airfield and should display a known altitude, within the limits specified in the aircraft operating manuals. The two primary altimeters should also agree within limits specified by the aircraft operating manual. An alternative procedure using QFE may also be used. Any required functioning checks of altitude indicating systems should be performed.

NOTE. *The maximum value for these checks cited in operating manuals should not exceed 23 m (75 ft.)*

- (d) before take-off, equipment required for flight in RVSM airspace should be operative, and any indications of malfunction should be resolved.

4. PROCEDURES PRIOR TO RVSM AIRSPACE ENTRY

The following equipment should be operating normally at entry into RVSM airspace:

- (a) Two primary altitude measurement systems.
- (b) One automatic altitude-control system.
- (c) One altitude-alerting device.

NOTE: Dual equipment requirements for altitude-control systems will be established by regional agreement after an evaluation of criteria such as mean time between failures, length of flight segments and availability of direct pilot-controller communications and radar surveillance.

- (d) Operating Transponder. An operating transponder may not be required for entry into all designated RVSM airspace. The operator should determine the requirement for an operational transponder in each RVSM area where operations are intended. The operator should also determine the transponder requirements for transition areas next to RVSM airspace.

NOTE: Should any of the required equipment fail prior to the aircraft entering RVSM airspace, the pilot should request a new clearance to avoid entering this airspace;

5. IN-FLIGHT PROCEDURES

5.1 The following practices should be incorporated into flight crew training and procedures:

- (a) Flight crews will need to comply with any aircraft operating restrictions, if required for the specific aircraft group, e.g. limits on indicated Mach number, given in the RVSM airworthiness approval.
- (b) Emphasis should be placed on promptly setting the sub-scale on all primary and standby altimeters to 1013.2 (hPa) /29.92 in.Hg when passing the transition altitude, and rechecking for proper altimeter setting when reaching the initial cleared flight level;
- (c) In level cruise it is essential that the aircraft is flown at the cleared flight level. This requires that particular care is taken to ensure that ATC clearances are fully understood and followed. The aircraft should not intentionally depart from cleared flight level without a positive clearance from ATC unless the crew are conducting contingency or emergency manoeuvres;
- (d) When changing levels, the aircraft should not be allowed to overshoot or undershoot the cleared flight level by more than 45 m (150 ft);

NOTE: It is recommended that the level off be accomplished using the altitude capture feature of the automatic altitude-control system, if installed.

- (e) An automatic altitude-control system should be operative and engaged during level cruise, except when circumstances such as the need to re-trim the aircraft or turbulence require disengagement. In any event, adherence to cruise altitude should be done by reference to one of the two primary altimeters. Following loss of the automatic height keeping function, any consequential restrictions will need to be observed.
- (f) Ensure that the altitude-alerting system is operative;
- (g) At intervals of approximately one hour, cross-checks between the primary altimeters should be made. A minimum of two will need to agree within ± 60 m (± 200 ft). Failure to meet this condition will require that the altimetry system be reported as defective and notified to ATC;
 - i. The usual scan of flight deck instruments should suffice for altimeter cross-checking on most flights.
 - ii. Before entering RVSM airspace, the initial altimeter cross check of primary and standby altimeters should be recorded

NOTE: Some systems may make use of automatic altimeter comparators.

- (h) In normal operations, the altimetry system being used to control the aircraft should be selected for the input to the altitude reporting transponder transmitting information to ATC.
- (i) If the pilot is advised in real time that the aircraft has been identified by a height monitoring system as exhibiting a TVE greater than ± 90 m (± 300 ft) and/or an ASE greater than ± 75 m (± 245 ft) then the pilot should follow established regional procedures to protect the safe operation of the aircraft. This assumes that the monitoring system will identify the TVE or ASE within the set limits for accuracy.
- (j) If the pilot is notified by ATC of an assigned altitude deviation which exceeds ± 90 m (± 300 ft) then the pilot should take action to return to cleared flight level as quickly as possible.

5.2 Contingency procedures after entering RVSM airspace are:

5.2.1 The pilot should notify ATC of contingencies (equipment failures, weather) which affect the ability to maintain the cleared flight level, and co-ordinate a plan of action appropriate to the airspace concerned. Detailed guidance on contingency procedures is contained in the relevant publications dealing with the airspace. Refer to Appendix 1, Paragraph 8 of this document.

5.2.2 Examples of equipment failures which should be notified to ATC are:

- (a) failure of all automatic altitude-control systems aboard the aircraft;
- (b) loss of redundancy of altimetry systems;
- (c) loss of thrust on an engine necessitating descent; or
- (d) any other equipment failure affecting the ability to maintain cleared flight level;

5.2.3 The pilot should notify ATC when encountering greater than moderate turbulence.

5.2.4 If unable to notify ATC and obtain an ATC clearance prior to deviating from the cleared flight level, the pilot should follow any established contingency procedures and obtain ATC clearance as soon as possible.

6. POST FLIGHT

6.1 In making technical log entries against malfunctions in height keeping systems, the pilot should provide sufficient detail to enable maintenance to effectively troubleshoot and repair the system. The pilot should detail the actual defect and the crew action taken to try to isolate and rectify the fault.

6.2 The following information should be recorded when appropriate:

- (i) Primary and standby altimeter readings.
- (j) Altitude selector setting.
- (k) Subscale setting on altimeter.
- (l) Autopilot used to control the aeroplane and any differences when an alternative autopilot system was selected.
- (m) Differences in altimeter readings, if alternate static ports selected.
- (n) Use of air data computer selector for fault diagnosis procedure.
- (o) The transponder selected to provide altitude information to ATC and any difference noted when an alternative transponder was selected.

7. SPECIAL EMPHASIS ITEMS: FLIGHT CREW TRAINING

7.1 The following items should also be included in flight crew training programmes:

- (a) knowledge and understanding of standard ATC phraseology used in each area of operations;
- (b) importance of crew members cross checking to ensure that ATC clearances are promptly and correctly complied with;
- (c) use and limitations in terms of accuracy of standby altimeters in contingencies. Where applicable, the pilot should review the application of static source error correction/ position error correction through the use of correction cards;

NOTE: Such correction data will need to be readily available on the flight deck.

- (d) problems of visual perception of other aircraft at 300 m (1,000 ft) planned separation during darkness, when encountering local phenomena such as northern lights, for opposite and same direction traffic, and during turns; and
- (e) characteristics of aircraft altitude capture systems which may lead to overshoots;
- (f) relationship between the aircraft's altimetry, automatic altitude control and transponder systems in normal and abnormal conditions;
- (g) any airframe operating restrictions, if required for the specific aircraft group, related to RVSM airworthiness approval.

1. INTRODUCTION

The application for RVSM approval must include an approved maintenance programme. This programme must outline procedures to maintain aircraft in accordance with the applicable regulations and the requirements of this Advisory Circular. The approved RVSM maintenance programme is not required to include elements not related to RVSM maintenance.

2. CONTENTS

Each RVSM maintenance programme must 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: *The above elements may be listed in detail or described by reference to an approved programme that is identified and controlled by revision or issue number.*

NOTE: *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.

3. Operators using the services of approved maintenance organisations must include provisions to ensure that the requirements of their RVSM programmes are being met.

End of Advisory Circular