



สำนักงานการบินพลเรือนแห่งประเทศไทย  
The Civil Aviation Authority of Thailand

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# GUIDANCE MATERIAL FOR Reduced Vertical Separation Minimum (RVSM)

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CAAT-OPS-GM-RVSM

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Approved by



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Director General of the Civil Aviation Authority of Thailand

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## GENERAL

Guidance Material (GM) are issued by The Civil Aviation Authority of Thailand (CAAT) and contain information about standards, practices and procedures acceptable to the Authority. The revision number of the GM is indicated in parenthesis in the suffix of the GM number.

## PURPOSE

The intention of this is This Guidance Material (GM) to provide:

- (a) Information on the approvals process
- (b) Guidance on the arrangements and need for monitoring.

## RELATED READING MATERIAL

- (a) International Civil Aviation Organization (ICAO) Document 4444, Procedures for Air Navigation Services, Air Traffic Management.
- (b) FAA AC 91-85B Authorization of Aircraft and Operators for Flight in Reduced Vertical Separation Minimum Airspace.
- (c) ICAO Annex 6, Operation of Aircraft. Part I–International Commercial Air Transport– Aeroplanes and Part II–International General Aviation–Aeroplanes.
- (d) ICAO Document 7030, Regional Supplementary Procedures.
- (e) ICAO Document 9574, Manual on Implementation of a 300 m (1,000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive.

## LIST OF ABBREVIATION

|        |   |
|--------|---|
| AAD    | Assigned altitude deviation                             |
| AC     | Advisory circular                                       |
| ACAS   | Airborne collision avoidance system                     |
| ACU    | Aircraft Certification Unit                             |
| ADC    | Air data computer                                       |
| AFM    | Airplane flight manual                                  |
| ADS-B  | Automatic dependent surveillance - broadcast            |
| AGHMEs | Aircraft geometric height measurement elements          |
| AHMS   | ADS-B height monitoring system                          |
| ASE    | Altimetry system error                                  |
| ATC    | Air traffic control                                     |
| BITE   | Built-in test equipment                                 |
| CFL    | Cleared flight level                                    |
| CAAT   | The Civil Aviation Authority of Thailand                |
| FAA    | Federal Aviation Administration                         |
| FL     | Flight level  |
| GMU    | Global positioning system monitoring unit               |
| GPS    | Global positioning system                               |
| HME    | Height monitoring element                               |
| HMU    | Height monitoring unit                                  |
| IATA   | International Air Transport Association                 |
| ICA    | Instructions for continued airworthiness                |
| ICAO   | International Civil Aviation Organization               |
| IFALPA | International Federation of Airline Pilots Associations |

|        |  |
|--------|--|
| IFATCA | International Federation of Air Traffic Controllers Associations             |
| MAAR   | Monitoring Agency for Asia Region  |
| MASPS  | Minimum aircraft system performance specification                            |
| MEL    | Minimum equipment list   |
| MNPS   | Minimum navigation performance specification                                 |
| NM     | Nautical mile  |
| PEC    | Position correction error  |
| PIC    | Pilot in command   |
| QFE    | Atmospheric pressure at aerodrome elevation (or at runway threshold)         |
| QNH    | Altimeter sub-scale setting to obtain elevation when on the ground           |
| RGCSP  | Review of the general concept of separation panel                            |
| RMA    | Regional monitoring agency   |
| RVSM   | Reduced vertical separation minimum of (300m) 1,000 ft between flight levels |
| SB     | Service bulletin   |
| SL     | Service letter   |
| SLOP   | Strategic lateral offset procedures  |
| SSEC   | Static source correction error   |
| SSR    | Secondary surveillance radar   |
| STC    | Supplemental type certificate  |
| TCAS   | Traffic alert and collision avoidance system                                 |
| TCDS   | Type certificate data sheet  |
| TLS    | Target level of safety   |
| TMU    | Total vertical error monitoring unit   |
| TVE    | Total vertical error   |
| VHF    | Very high frequency  |
| VSM    | Vertical separation minimum  |

## LIST OF DEFINITIONS

The following definitions are intended to clarify certain specialized terms used in this guidance material (GM).

### **Automatic dependent surveillance – broadcast (ADS-B):**

ADS-B is an on-board surveillance application that periodically transmits aircraft parameters, such as identification, pressure altitude, position and position integrity, via a broadcast data link that is available to any receiver, either airborne or ground-based, within range of the transmitter.

### **Aircraft type groupings:**

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

### **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 transponded altitude and the assigned altitude/flight level.

### **Non-compliant aircraft:**

An aircraft whose true absolute TVE, ASE or AAD is greater than the maximum acceptable value for RVSM-approved aircraft.

**RVSM approval:**

The term used to describe the successful completion of the airworthiness approval and operational approval.

**Target level of safety (TLS):**

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

**Total vertical error (TVE):**

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

## GUIDANCE MATERIAL FOR RVSM

### 1. Introduction and background

#### 1.1 Introduction

RVSM airspace is any airspace or route where aircraft are separated by 1,000 ft vertically, between FL 290 and FL 410, inclusive. Generally, aircraft and operators that have not been authorized to conduct RVSM operations cannot operate at flight levels where RVSM is applied. Exceptions to this rule are published by individual air traffic service providers.

RVSM was first implemented in the North Atlantic in March 1997. Since that time, it has been implemented in most regions of the world, and RVSM approval is required for flight operations conducted between FL 290 and FL 410; although in some locations it is only required between FL 310 and FL 390.

The intention of this Guidance Material is to provide:

- (a) information on the approvals process
- (b) guidance on the arrangements and need for monitoring.

#### 1.2 Background

In 1982 the ICAO initiated a series of world-wide studies to assess the feasibility of a reduction of the VSM above FL 290 from 2,000 ft to 1,000 ft. The studies were co-ordinated by the review RGCSF which included representation from the IATA, IFALPA and the IFATCA. The principal benefits which the implementation of the reduced VSM were expected to provide were:

- (a) a theoretical doubling of the airspace capacity between FL 290 and FL 410
- (b) the opportunity for aircraft to operate at/closer to their optimum flight levels, with resulting fuel economy.

Studies and data collections were conducted in Canada, Japan, USA, USSR and four member states of Euro control: France, Germany, Netherlands and United Kingdom. These studies were essentially intended to determine the following:

- (a) the height keeping accuracy of the current aircraft population at/above FL 290
- (b) the causes of height deviations greater than 300 ft and to define corrective measures
- (c) the basis of the MASPS to support the use of a 1,000 ft vertical separation above FL 290.

As a result, the RGCSF concluded that a 1,000 ft VSM between FL 290 and FL 410 was technically feasible without imposing unreasonably demanding technical or operational requirements. The ICAO Air Navigation Commission endorsed these findings in 1990.

With the exception of a small number of states, RVSM was progressively introduced globally between 1997 and 2011, and operation within this airspace is prohibited unless the operator has RVSM approval for the aircraft being flown, or an exception has been granted for a specific flight.

## **2. RVSM Approval Overview**

### **2.1 General**

Prior to the granting of an RVSM approval the aircraft and operator must satisfy the following requirements:

- (a) the aircraft must be eligible for RVSM (i.e. must satisfy the vertical navigation performance)
- (b) the operator has instituted appropriate procedures in respect of continued airworthiness (maintenance and repair) practices and programs
- (c) the operator has instituted appropriate flight crew procedures and training for operations in RVSM airspace
- (d) the operator has instituted RVSM monitoring programs.

The RVSM approval process consists of two discrete approvals, an airworthiness approval and an operational approval.

## **2.2 Airworthiness approval (including continued airworthiness)**

The RVSM airworthiness approval ensures that the aircraft is eligible to operate in RVSM airspace. During the RVSM airworthiness approval process the CAAT will determine whether the operator's aircraft is eligible for RVSM, this includes the aircraft's instructions for continued airworthiness (ICA) (i.e. maintenance program, maintenance manuals and maintenance training). Aircraft compliance will be conducted through one of three broad categories.

(a) Existing RVSM compliance by manufacturer. For aircraft manufactured in an RVSM compliant condition, the CAAT will determine that the AFM or TCDS contains an appropriate statement of RVSM eligibility and that approval of the RVSM eligibility was made by an authority acceptable to the Director. For aircraft that qualify for this approach, validation height monitoring will typically be conducted after an RVSM approval is granted.

(b) Existing RVSM compliance by inspection/modification. This approach is suitable for aircraft that are brought up to RVSM-compliant condition in accordance with SB, SL, or STC, which have had the RVSM eligibility approved by an authority acceptable to the Director. These documents contain requirements that are specific to individual aircraft types or aircraft type groups and generally require inspections and/or hardware or software modifications. The operator must submit documents to the CAAT to show that the required actions have been completed for each airframe that will operate in RVSM airspace. For aircraft that qualify for this approach, validation height monitoring will typically be conducted after an RVSM approval is granted.

(c) Bespoke RVSM compliance by inspection/modification. This approach will be undertaken where an operator intends to gain RVSM approval for aircraft of a type or aircraft type group which have not previously gained the RVSM airworthiness approval of the RVSM approval. In this case the CAAT, in consultation with the applicant, will tailor an airworthiness approval process in order to demonstrate compliance. Further detail regarding performance requirements and means of demonstrating RVSM airworthiness can be found in *FAA advisory circular AC91-85B Authorization of Aircraft and Operators for Flight in Reduced Vertical Separation Minimum Airspace, and ICAO document 9574 Manual on Implementation of a 300m (,1,000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive*.

For aircraft which require this approach, validation monitoring will typically be conducted prior to an RVSM approval being granted.

In all cases, the operator is to provide the CAAT with supporting documentation to demonstrate RVSM airworthiness compliance (including continued airworthiness compliance) of all the aircraft they intend to operate in RVSM airspace. Dependent upon the specific situation, relevant documents might include the following.

- (a) AFM or AFMS
- (b) TCDS
- (c) SB or STC
- (d) MEL
- (e) Initial height validation monitoring plan.
- (f) Instructions for RVSM Continued Airworthiness (for example: maintenance manuals).

*Note: As part of the RVSM airworthiness approval the aircrafts height performance is to be validated. Initial height validation monitoring requirements will be determined during the initial application phase; Appendix 4 provides more detail on initial height validation monitoring. It is recommended that applicants contact the DCA to discuss monitoring requirements and acceptable methods available at the time of application.*

### **2.3 Operational approval**

The RVSM operational approval ensures that the operator can maintain the RVSM integrity of each aircraft that is to be operated in RVSM airspace. During the RVSM operational approval process CAAT will assess the operator's flight crew procedures, maintenance procedures, training programs and RVSM continued height monitoring program for each aircraft type. Operators are to provide supporting documentation to demonstrate RVSM operational compliance, relevant documents include:

- (a) operations manual (RVSM flight operations)

- (b) maintenance program (RVSM continued airworthiness)
- (c) RVSM continued height monitoring plan
- (d) RVSM training programs:
  - (i) maintenance training
  - (ii) flight crew training.

*Note: In 2010 ICAO identified the requirement for continued height-keeping performance monitoring of RVSM capable aircraft in order to ensure continued RVSM suitability; Appendix 4 provides more detail on continued height monitoring. The operator is to have a program in place to ensure that their RVSM approved aircraft are involved in a continued RVSM height monitoring program.*

Appendix 1 provides detailed information on RVSM continued airworthiness (maintenance requirements). Appendix 2 provides detailed information on flight crew training programs, operating practices and procedures. Appendix 3 provides detailed information on RVSM specific procedures for oceanic airspace and Appendix 4 provides detailed information on RVSM monitoring.

### **3. Application and Issue of Approval**

An application for an RVSM approval shall be submitted on the form CAAT Operational Approval Application, with a covering letter requesting RVSM approval and any pertinent information pertaining to the application, including:

- (a) operator details
- (b) aircraft type and series
- (c) registration number
- (d) manufacturer's serial number
- (e) aircraft mode S address code in hexadecimal format

(f) sufficient documentation demonstrating RVSM compliance as detailed in this guidance material.

*Note: In the case of aircraft manufactured to the same aircraft type group, only one application is required. Aircraft are considered to be members of the same group if they are designed and assembled by one manufacturer and are of nominally identical design and build with respect to all details which could influence the accuracy of height-keeping performance. In all other cases an application for each aircraft is required.*

Forms of Application for Approval or Revision of a Minimum Equipment List and Application for Approval/Amendment of a Maintenance Program are also to be submitted as part of the application.

When all the requirements of the airworthiness approval and operational approval have been assessed as satisfactory, CAAT will issue a letter of notification of approval and the operator's air operator certificate – operations specifications will be updated to reflect the RVSM approval. An RVSM approval issued by the CAAT is valid for all regions operating RVSM airspace provided specific restrictions have not been imposed on the operator by CAAT.

Subject to completeness and timeliness of documents submission the processing of RVSM Operational approval would require 30 working days.

Once an RVSM approval has been granted, the CAAT will notify MAAR. The notification will include:

- (a) state of registry of the aircraft
- (b) name of the operator
- (c) state of the operator
- (d) aircraft type
- (e) aircraft series
- (f) aircraft serial number(s)

- (g) registration mark
- (h) Mode S address code(s)
- (i) date of RVSM airworthiness approval
- (j) date of RVSM approval.

*Note: The date of airworthiness approval issued by the CAAT should be the actual date that the modifications/inspections were completed for each airframe.*

#### **4. APPROVAL LIMITATION**

RVSM operational approval is aircraft and operator specific; any changes to the identity of the aircraft or operator shall render the RVSM operational approval invalid and the Authority shall be informed of such changes without delay.

Subject to compliance with ICAO Document 7030, Regional Supplementary Procedures, and State AIPs, the RVSM operational approval is valid worldwide.

#### **5. HEIGHT-KEEPING PERFORMANCE MONITORING**

Once the operational approval to conduct RVSM operations is granted by DCA, the operator will complete a MAAR Form F2 (USC Form 2 for EUROCONTROL User Support Cell) for the Authority to submit to the RMA (Regional Monitoring Agency), MAAR for Asia region, for conduct of Aircraft Height-Keeping Performance Monitoring flight.

This Height-Keeping Performance monitoring flight must be conducted within 6 months of the RVSM operational approval.

#### **6. CONTINUING COMPLIANCE OF MASPs**

The operator shall set in place a program to ensure that a minimum of two aeroplanes of each aeroplane-type grouping undergo height-keeping performance monitoring at least once every two years or within intervals of 1000 flight hours per aeroplane, whichever period is the longer.

If the operator's aeroplane-type grouping consists of a single aeroplane, the height-keeping monitoring of that aeroplane shall be accomplished within the specified period.

## 7. Conditions for Removal of an RVSM Approval

The incidence of height-keeping errors that can be tolerated in an RVSM environment is very small. It is incumbent upon each operator to take immediate action to rectify the conditions that caused the error. The operator should also report the event to the CAAT within 72 hours with initial analysis of causal factors and measures to prevent further events. CAAT will determine the requirement for follow up reports. Errors which should be reported and investigated are: TVE equal to or greater than  $\pm 300$  ft ( $\pm 90$  m), ASE equal to or greater than  $\pm 245$  ft ( $\pm 75$  m), and AAD equal to or greater than  $\pm 300$  ft ( $\pm 90$  m).

Height-keeping errors fall into two broad categories:

- (a) errors caused by malfunction of aircraft equipment
- (b) operational errors.

An operator who consistently commits errors of either variety may be required to forfeit authority for RVSM operations. If a problem is identified that is related to one specific aircraft type, then RVSM approval may be removed for the operator for that specific type. Another condition for the removal of RVSM approval is the change of ownership of RVSM approved aircraft. As part of the RVSM approval, CAAT assesses the operator to ensure that they have implemented the required programs and procedures to ensure that the integrity of RVSM is maintained – this cannot be transferred with the aircraft.

## **APPENDIX 1: RVSM CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS)**

Instructions for continued airworthiness verify the integrity of the design features necessary to ensure that altimetry systems continue to meet RVSM standards through scheduled tests and/or inspections in conjunction with an approved maintenance program. The operator should review its maintenance procedures and address all aspects of continuing airworthiness affected by RVSM requirements. Each person or operator should demonstrate that the maintenance facility is adequate to ensure continued compliance with the RVSM maintenance requirements.

### **A1.1 Maintenance program approval requirements**

Each operator requesting an RVSM operational approval should submit a maintenance and inspection program that includes any maintenance requirements defined in the airworthiness approval.

### **A1.2 Maintenance document review requirements**

Review the following items as appropriate for an RVSM operational approval:

- (a) maintenance manuals
- (b) structural repair manuals
- (c) standards practices manuals
- (d) illustrated parts catalogues
- (e) maintenance schedule
- (f) MMEL / MEL.

### **A1.3 Maintenance practices**

If the operator's aircraft are subject to an approved maintenance program, that program should contain the maintenance practices outlined in the applicable aircraft and component manufacturer's maintenance manuals for each aircraft type. Review the following items for compliance for RVSM

approval. If the operator's aircraft is not subject to an approved maintenance program, the following items should be followed.

(a) Maintain all RVSM equipment in accordance with the component manufacturer's maintenance requirements.

(b) Any modification, repair, or design change that in any way alters the initial RVSM approval should be subject to a design review by persons approved by the approving authority.

(c) Refer any maintenance practices that may affect the continuing RVSM approval integrity (for example: the alignment of pilot/static probes, dents, or deformation around static plates) to the approving authority or persons delegated by the authority.

(d) BITE testing is not an acceptable basis for system calibrations, (unless it is shown to be acceptable by the airframe manufacturer with the approval authority's agreement) and should only be used for fault isolation and troubleshooting purposes.

(e) Some aircraft manufacturers have determined that the removal and replacement of components utilizing quick disconnects and associated fittings, when properly connected, will not require a leak check. While this approach may allow the aircraft to meet static system certification standards when properly connected, it does not always ensure the integrity of the fittings and connectors, nor does it confirm system integrity during component replacement and reconnections. Therefore, a system leak check or visual inspection should be accomplished any time a quick disconnect static line is broken.

*Note: If both quick disconnects are broken for any reason, a leak-check must be done.*

(f) Maintain airframe and static systems in accordance with the airframe manufacturer's inspection standards and procedures.

(g) If necessary, 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 should be made to ensure adherence to the airframe manufacturer's RVSM tolerances. Perform these tests and

inspections as established by the airframe manufacturer. Perform these checks following repairs, or alterations that affect RVSM by having an effect on airframe surface and airflow.

(h) The maintenance and inspection program for the autopilot should 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 to ensure the equipment is serviceable.

(i) Where the applicant demonstrates the performance of existing equipment is satisfactory for RVSM approval, CAAT should verify that the existing maintenance practices are also consistent with continued RVSM approval integrity. Examples include:

- (a) altitude alert
- (b) automatic altitude control system
- (c) ATC altitude reporting equipment
- (d) altimetry systems.

#### A1.4 Maintenance practices for noncompliant aircraft

Those aircraft positively identified as exhibiting height-keeping performance errors which require investigation as specified under section 8 should not be operated under an RVSM approval in airspace where RVSM is applied until the following actions have been taken:

- (a) the failure or malfunction is confirmed and isolated by maintenance action
- (b) corrective action is carried out and verified to ensure RVSM approval integrity.

#### A1.5 Maintenance training requirements

The RVSM approval process should include a review of the operator's maintenance training program as it relates to the equipment required for RVSM operations. Emphasize the following curriculum segments for initial and recurrent training of shop and line personnel:

- (a) aircraft geometric inspection techniques
- (b) test equipment calibration/usage techniques
- (c) any special documentation or procedures introduced by RVSM approval.

#### A1.6 Test equipment

The test equipment should have the capability to demonstrate continuing compliance with the parameters established for RVSM approval in the initial data package or as approved by the approving authority.

Test equipment should be calibrated using approved reference standards traceable to the national standard. Calibrate at periodic intervals as agreed by the approving authority. The approved maintenance program should incorporate effective quality control measures including the following.

- (a) Definition of required test equipment accuracy.
- (b) Regular calibrations of test equipment traceable to the approved standard.

*Note: Determination of calibration interval should be a function of the stability of the test equipment. Establish the calibration interval based on historical data so that degradation is small in relation to the required accuracy.*

- (c) Procedures to ensure conducting of regular audits of calibration facilities both in-house and outside.
- (d) Adherence to acceptable shop and line maintenance practices.
- (e) Procedures for controlling operator errors and unusual environmental conditions that may affect calibration accuracy.

## **APPENDIX 2: FLIGHT CREW TRAINING PROGRAMS, OPERATING PRACTICES AND PROCEDURES**

The following items (detailed in A2.2 to A2.8) should be standardized and incorporated into training program and operating practices and procedures. Certain items may already be adequately standardized in existing operator programs and procedures. New technologies may also eliminate the need for certain crew actions. If this is the case, then the intent of this guidance can be considered to be met.

### **A2.1 Flight planning**

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

- (a) verifying that the aircraft is approved for RVSM operations
- (b) block 10 (equipment) of the ICAO flight plan should be annotated with the letter W for filing in RVSM airspace
- (c) reported and forecast weather conditions on the route of flight
- (d) minimum equipment requirements pertaining to height-keeping systems
- (e) if required for the specific aircraft group; accounting for any aircraft operating restrictions related to RVSM airworthiness approval.

### **A2.2 Pre-flight procedures**

Accomplish the following actions during pre-flight.

- (a) Review maintenance logs and forms to ascertain the condition of equipment required for flight in the RVSM airspace. Ensure that maintenance action has been taken to correct defects to required equipment and that minimum equipment requirements pertaining to height-keeping systems are met.

(b) During the external inspection of aircraft, pay particular attention 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. (A qualified and authorized person other than the pilot, for example: a flight engineer or maintenance personnel may perform this check).

(c) Before take-off, the aircraft altimeters should be set to the local altimeter atmospheric pressure at nautical height (QNH) setting and should display a known elevation (for example: field elevation) within the limits specified in aircraft operating manuals. The difference between the known elevation and the elevation displayed on the altimeters should not exceed 75 ft. The two primary altimeters should also agree within limits specified by the aircraft operating manual. An alternative procedure using atmospheric pressure at field elevation (QFE) may also be used.

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

### **A2.3 Procedures before RVSM airspace entry**

If any of the required equipment fails prior to the aircraft entering RVSM airspace, the pilot should request a new clearance so as to avoid flight in this airspace. The following equipment should be operating normally at entry into RVSM airspace:

- (a) two serviceable independent primary altitude measurement systems
- (b) one automatic altitude-control system
- (c) one altitude-alerting device.

Note: Single source dependency following ADC failure does not meet the criteria for RVSM operation. The operator should ascertain the requirement for an operational transponder in each RVSM area where operations are intended.

## A2.4 In-flight procedures

Incorporate the following policies into flight crew training and procedures.

(a) Flight crews should comply with aircraft operating restrictions (if required for the specific aircraft group) related to RVSM airworthiness approval.

(b) Place emphasis on promptly setting the sub-scale on all primary and standby altimeters to 29.92 in.Hg/1013.2 (hPa) when passing the transition altitude and rechecking for proper altimeter setting when reaching the initial cleared flight level (CFL).

(c) In level cruise, it is essential that the aircraft is flown at the CFL. This requires that particular care is taken to ensure that ATC clearances are fully understood and followed. Except in contingency or emergency situations, the aircraft should not intentionally depart from CFL without a positive clearance from ATC.

(d) During cleared transition between levels, the aircraft should not be allowed to overshoot or undershoot the CFL by more than 150 ft (45 m).

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

High rates of climb or descent may result in nuisance TCAS alerts on older TCAS equipment (TCAS 7.0) when in vicinity of other traffic or in areas of high traffic density. For this reason it may be advisable to reduce the rate of climb/descent to less than 1,000 ft/min within 1,000 ft of the cleared flight level.

(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.

(f) The altitude-alerting system should be operational.

(g) At intervals of approximately one hour, make cross-checks between the primary altimeters and the stand-by altimeter. A minimum of two primary altimeters should agree within 200 ft (60 m) or a lesser value if specified in the aircraft operating manual. (Failure to meet this condition will require that the altimetry system be reported as defective and notified to ATC). Note the difference between the primary and stand-by altimeters for use in contingency situations.

(i) The normal pilot scan of cockpit instruments should suffice for altimeter crosschecking on most flights.

(ii) When operating under positive radar control, the initial altimeter cross-check should be performed after level off. On Class II navigation legs, a cross-check should be performed and recorded in the vicinity of the point where Class II navigation is begun (for example: on coast out). The readings of the primary and standby altimeters should be recorded and available for use in contingency situations.

(iii) Some aircraft have automatic comparators that compare the two primary altimetry systems. The comparators include a monitoring, warning, and fault function. The faults may be recorded automatically by the system but a record of the differences in the primary altimetry systems may not be easily derived.

*Note: Future systems may make use of automatic altimeter comparators in lieu of cross-checks by the crew.*

(h) Crew should ensure the autopilot used and the transponder selected use the same air data source for altitude information.

(i) If ATC notifies the pilot of an AAD error that equals or exceeds 300 ft (90 m) then the pilot should take action to return to CFL as quickly as possible.

(j) Contingency procedures after entering RVSM airspace. The pilot should notify ATC of contingencies (aircraft system failures, weather conditions) which affect the ability to maintain the CFL and coordinate a plan of action.

## A2.5 Equipment failures

ATC shall be informed as soon as practicable of the following equipment failures:

- (a) loss of one or more primary altimetry systems
  
- (b) failure of any relevant altitude control systems.

## A2.6 Post flight

In making maintenance logbook 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. Note the following information when appropriate:

- (a) primary and standby altimeter readings
- (b) altitude selector setting
- (c) subscale setting on altimeter
- (d) autopilot used to control the airplane and any differences when the alternate system was selected
- (e) differences in altimeter readings if alternate static ports selected
- (f) use of air data computer selector for fault diagnosis procedure
- (g) transponder selected to provide altitude information to ATC and any difference if alternate transponder or altitude source is manually selected.

## **A2.7 Special emphasis items: flight crew training**

The following items should also be included in flight crew training programs.

- (a) Area of operations specific policy and procedures including standard ATC phraseology.
- (b) Importance of crew members cross checking each other 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 SSEC/PEC through the use of correction cards.
- (d) Problems of visual perception of other aircraft at 1,000 ft (300 m) planned separation during night conditions, when encountering local phenomena such as northern lights, for opposite and same direction traffic, and during turns.
- (e) Characteristics of aircraft altitude capture systems that may lead to the occurrence of overshoots.
- (f) Operational procedures and operating characteristics related to TCAS / ACAS operation in an RVSM operation.
- (g) Relationship between the altimetry, automatic altitude control, and transponder systems in normal and abnormal situations.
- (h) Aircraft operating restrictions (if required for the specific aircraft group) related to RVSM airworthiness approval.
- (i) For those operators authorized to conduct oceanic operations – use of SLOP in oceanic airspace to mitigate the effect of wake turbulence and the effect of operational errors.

### **APPENDIX 3: SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE**

RVSM was initially implemented in North Atlantic MNPS airspace in March 1997. The guidance that follows has been applied in the North Atlantic region since that time. It is also applied to RVSM operations in the Pacific, West Atlantic and other oceanic airspace.

This appendix contains information on procedures that are unique to oceanic RVSM airspace where direct voice communications between pilots and ATC is not available.

#### **A3.1 Basic concepts for contingencies**

The basic concepts for contingencies described in this paragraph were developed from the specific guidance contained in ICAO Document 4444, Chapter 15, Procedures Related to Emergencies, Communication Failure and Contingencies. Contingency procedures become complicated when specific situations are detailed. However, if the details are examined in the context of certain basic concepts, then they are more easily understood. Reviewing these concepts should serve to aid pilots' understanding of the specific contingency procedures detailed in ICAO Document 4444. Contingency procedures published in ICAO Document 7030, Regional Supplementary Procedures, provide differences for individual regions of the world.

## APPENDIX 4: RVSM MONITORING

### A4.1 RVSM height monitoring programs

A program to monitor or verify aircraft height-keeping performance is considered a necessary element of RVSM. RVSM monitoring programs have the primary objective of observing and evaluating aircraft height-keeping performance to gain confidence that airspace users are applying the airplane/operator RVSM approval in an effective manner and that an equivalent level of safety will be maintained.

#### A4.1.1 Initial height validation monitoring

The RVSM airworthiness approval of an RVSM approval requires that the aircraft and operator be involved in an RVSM initial height validation monitoring program. The initial height validation monitoring program validates the aircraft's height performance for RVSM operations. For most aircraft types, monitoring is not required to be completed prior to operational approval being granted. The categories of monitoring are detailed below.

- (a) Aircraft type group approved aircraft (data indicates compliance with RVSM MASPS). Two airframes from each fleet of an operator are to be monitored as soon as possible but not later than 6 months after the issue of an RVSM approval.
- (b) Aircraft type group approved aircraft (insufficient data on approved aircraft). Sixty percent of airframes (round up if fractional) from each fleet of an operator are to monitor or individual monitoring, as soon as possible but not later than six months after the issue of an RVSM approval.
- (c) Bespoke / non-group aircraft. One hundred percent of aircraft shall be monitored prior to the granting of an RVSM approval.

*Note: Contact with DCA is required to clarify / confirm that the operator's aircraft are in the appropriate category.*

(d) Aircraft status for monitoring. Aircraft engineering work required for the aircraft to receive RVSM airworthiness approval must be completed prior to the aircraft being monitored.

(e) Monitoring of airframes that are RVSM compliant on delivery. If an operator adds new RVSM compliant airframes of a type for which it already has RVSM approval, providing the operator has completed monitoring requirements for the type, the new airframes are not required to be monitored – except as targeted at a later date in the continued monitoring program. If an operator adds new RVSM compliant airframes of an aircraft type for which it has not previously received RVSM approval, then the operator is to complete monitoring in accordance with this advisory circular.

(f) Applicability of monitoring from other regions. Monitoring data obtained in conjunction with monitoring programs from other regions can be used to meet pacific monitoring requirements. MAAR administers the monitoring program in the FIRs for which it is responsible, and has access to monitoring data from other regions and will coordinate with states and operators to inform them on the status of individual operator monitoring requirements.

#### **A4.1.2 Continued height monitoring program**

A requirement of the RVSM operational approval is that the operator establishes a continued height monitoring program. This program is to ensure that a minimum of two aircraft of each aircraft type grouping of the operator have their height-keeping performance monitored, at least once every two years or within intervals of 1,000 flight hours per aircraft, whichever period is longer. If an operator aircraft type grouping consists of a single aeroplane, monitoring of that aeroplane shall be accomplished within the specified period.

*Note: A height-monitoring system based on global positioning satellites or an earth-based system may fulfill this function.*

*Monitoring data from any regional monitoring program established in accordance with ICAO Annex 11, 3.3.5.2, may be used to satisfy the requirement.*

#### A4.2 RVSM monitoring methods

There are multiple methods and agencies for performing RVSM height monitoring. There are four categories.

(a) Height monitoring units (HMUs). In operation in Europe, US and Japan. HMU is a ground-based system consisting of two main components – height monitoring element (HME) and total vertical error monitoring unit (TMU).

(i) The HME captures SSR transponder signals from aircraft replying to Interrogations from radar stations. The signals contain the information from mode S and mode A / C transmissions. The HME determines the geometric height and position of an aircraft by comparing the time of reception of the SSR transponder signals at different receiver locations. This information is transmitted to the TMU as one plot per second. The data is collated by the TMU to create a track history of the aircraft passing through the area of coverage. The track information is then combined with meteorological data to evaluate the overall value for TVE.

(ii) When completed, the monitoring process produces TVE, AAD and ASE readings for each aircraft measured. This data is fed to the region's monitoring agency. Currently there are no HMUs in the pacific region but there are multiple HMUs available in other regions. Contact CAAT for further information.

(b) Aircraft geometric height measurement elements (AGHMEs). A ground-based height monitoring system in operation in the US and Canada. The AGHME system does not require that any special monitoring devices be installed on an aircraft in order that it is monitored. It is necessary, however, transponder. Straight and level flight through the centre of the AGHME coverage area between FL 290 and FL 410 is required. Contact DCA for further information.

(c) ADS-B height monitoring system (AHMS). A ground-based height keeping performance monitoring system that utilizes geometric height data available from automatic dependant surveillance - broadcast

(ADS-B) equipped aircraft in order to calculate the ASE. Monitoring in airspace where a wide-area ADS-B network is available will not require an aircraft to specifically overfly any specific AHMS site, as normal flight operations can be monitored on a continuous basis with no operational impact. The use of ADS-B as a means to estimate ASE and comply with the ICAO Annex 6. 'Continued height-keeping monitoring requirements' has been endorsed by ICAO. Currently, the use of ADS-B for continued height keeping monitoring purposes is operational in the US, Australia, China and Asian RVSM regions. Contact DCA for further information.

*Note: ICAO has endorsed AHMS (ADS-B) as a means for continued height-keeping monitoring. AHMS (ADSB) is also a means to meet the initial validation height-keeping monitoring requirements.*

(d) GPS monitoring units (GMU). GMUs are a portable aircraft-based height monitoring unit. The GMU process requires straight and level flight between FL 290 and FL 410 where the GMU provider or operator will monitor the aircraft's height performance. The GMU provider will then process the data by applying differential corrections to the raw GPS data. They then submit it to PARMO where they determine the TVE. GMU monitoring is conducted globally. Contact CAAT for further information.

#### **A4.3 RVSM regional monitoring agencies (RMAs)**

RMAs are agencies that ICAO has approved following the global implementation of RVSM. These agencies ensure the safe use of specific airspace designated by regional agreement by assessing how successfully the airspace meets the agreed TLS. The target is determined by ICAO and depends on satisfactory aircraft height-keeping performance and measurement of risk associated with operational errors.

##### **A4.3.1 Monitoring Agency for Asia Region (MAAR)**

MAAR was established by Aeronautical Radio of Thailand, Ltd. (AEROTHAI) under the approval of the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) to assume the duties and responsibilities of the Regional Monitoring Agency (RMA) for the Asia Region.

The principal role of the MAAR is to assist the International Civil Aviation Organization (ICAO) in the continuation of the safety assessment program for the implementation of Reduced Vertical Separation Minimum (RVSM) and other monitoring requirements as determined by the APANPIRG.

Thailand registered aircraft with an RVSM approval are registered with MAAR. MAAR maintains a central registry of state RVSM approvals of operators and aircraft using the pacific region airspace where RVSM is applied. MAAR is responsible for determining whether an operator's fleet has demonstrated acceptable height keeping performance.