

State of Kuwait

Directorate General of Civil Aviation

Aviation Safety Department

GUIDANCE MATERIAL FOR OPERATIONS IN REDUCED VERTICAL SEPARATION AIRSPACE MANUAL (RVSM)

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GUIDANCE MATERIAL FOR OPERATIONS IN REDUCED VERTICAL SEPARATION AIRSPACE MANUAL

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Foreword

This is an DGCA procedure manual. It contains guidance material procedures intended to assist Air Operators of aircraft registered in the State of Kuwait to be aware of the requirements for the approval of Operations within areas designated as Reduced Vertical Separation Minimum (RVSM) Airspace and may be made available to the public for information purposes only. This manual is intended to aid the user in complying with the Kuwait Civil Aviation Safety Regulations (KCASR).

It is hereby declared that the attached Guidance Material for Operations in Reduced Vertical Separation Airspace Manual (Issue 2, Revision 0, May 2025) is approved.

Approved By:

Aviation Safety Director

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Dated: 01/06/2025

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GUIDANCE MATERIAL FOR OPERATIONS IN REDUCED VERTICAL SEPARATION AIRSPACE MANUAL

1.0 PURPOSE

The purpose of the Reduced Vertical Separation Minimum Airspace Guidance Material is to make Air Operators of aircraft registered in the State of Kuwait aware of the requirements for the approval of Operations within areas designated as Reduced Vertical Separation Minimum (RVSM) Airspace. This document provides information on the implementation plan, required equipment, approval process, well as guidance on operational procedures and training.

2.0 BACKGROUND

RVSM refers to airspace between flight level (FL) 290 and FL 410, with assigned altitudes separated by a minimum of 1,000 feet rather than the 2,000 foot minimum separation currently required above FL 290. The current requirement is based on navigation equipment with a level of accuracy that necessitated a 2,000 foot buffer. Modern navigation equipment permits more precise navigation, including altitude control. These regulations require Air Operators and their aircraft to be approved in accordance with new requirements, in order to operate in RVSM specified airspace. The regulations ensure that Air Operators and their aircraft are properly qualified and equipped to conduct flight operations while separated by 1,000 feet, and ensure that compliance with the RVSM requirements is maintained. This amendment makes more tracks and altitudes available for air traffic control to assign to Air Operators, thus increasing efficiency of operations and air traffic capacity. RVSM will be applied in designated airspace, North Atlantic (NAT), Pacific, Europe (proposed implementation January 24, 2001) and Middle East (proposed implementation November 2003).

3.0 REFERENCES

- 1) Federal Aviation Administration (FAA)
Document 91 – RVSM – Interim Guidance Material on the Approval of Operators/Aircraft for RVSM Operations
- 2) International Civil Aviation Organization (ICAO)
ICAO Document 9574 – Manual on the Implementation of a 300 m
(1000 ft) Vertical Separation Minimum Between FL 290 – FL 410 Inclusive

ICAO Document – Guidance Material on the Implementation and Application of a 300 m (1,000 ft) Vertical Minimum

ICAO Document 9536 – Review of the General Concept of Separation (RGCSF)

ICAO Document 7030/4 – Regional Supplementary Procedures (for appropriate region)
EUROCONTROL Document Volume II of the RGCSF/6 report –

Manual for Reduced Vertical Separation (RVSM) in Europe



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4.0 DEFINITIONS AND ABBREVIATIONS

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.

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.

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 c **RVSM Approval** The approval that is issued by the Kuwait DGCA.

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

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.



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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.

Abbreviation	Meaning
AAD	Assigned Altitude Deviation
ADC	Air Data Computer
AOA	Angle of Attack
AOC	Air Operator's Certificate
ASE	Altimetry System Error
ATS	Air Traffic Service
δ	Atmospheric Pressure Ratio
Hp	Pressure Altitude
hPa	Hecto-Pascals
in.Hg	Inches of Mercury
M	Mach number
MASPS	Minimum Aircraft System Performance Specification
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
Mmo	Maximum Operating Limit Mach
MNPS	Minimum Navigation Performance Specification
NAT	North Atlantic
NOTAM	Notice to Airmen
OAT	Operational Air Traffic
OTS	Organized Track Structure
QFE	Atmospheric pressure at aerodrome elevation (or at runway threshold)
QNH	Altimeter sub-scale setting to obtain elevation when on ground
RTF	Radio Telephony
SSE	Static Source Error
SSEC	Static Source Error Correction
TVE	Total Vertical Error
VMO	Maximum Operating Limit Velocity
W	Weight.

characteristics of the unique airframe rather than on a group basis.



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5.0 THE APPROVAL PROCESS

5.1 General

Airspace where RVSM is applied should be considered special qualification airspace. The specific aircraft type or types that the Air Operator intends to use will need to be approved by the Kuwait DGCA 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 material provides guidance for the approval of specific aircraft type or types, and for operational approval.

5.2 Approval of Aircraft

- 5.2.1 Each aircraft type that an operator intends to use in RVSM airspace should have received RVSM airworthiness approval from the State of Registry, in accordance with paragraph 8, prior to approval being granted for RVSM operations, including the approval of continued airworthiness programs. Paragraph 8 provides guidance for the approval of newly built aircraft and for aircraft that have already entered service. Paragraph 8 contains guidance on the continued airworthiness (maintenance and repair) programs for all RVSM operations.

5.3 Operational Approval

For certain airspace, as defined by ICAO Regional Navigation Agreements, Air Operators are required to hold State approval to operate in that airspace, which may or may not include RVSM. Paragraph 10 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 Kuwait DGCA.

6.0 RVSM PERFORMANCE

6.1 General

The statistical performance statements of ICAO Doc. 9574 for a population of aircraft (see Appendix 6) have been translated into airworthiness standards by assessment of the characteristics of ASE and altitude control. The following standards differ in some respects from that document, but they are consistent with the requirements of RVSM.

6.2 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 4 and explained in 8.4. For the Full envelope, a larger ASE is allowed.



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6.3 Altimetry System Error

6.3.1 To evaluate a system against the ASE performance statements established by RGCSP (see Appendix 5, paragraph 2), 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.
- (c) airframe to airframe variability of static source error.
- (d) effect of flight operating conditions on static source error.

6.3.2 Assessment of ASE, whether based on measured or predicted data will need to consider subparagraphs (a) to (d) of 6.3.1. 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.

6.3.3 The criteria to be met for the Basic RVSM envelope are:

- (a) At the point in the Basic RVSM 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 Basic RVSM 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).

6.3.4 The criteria to be met for the Full RVSM 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 RVSM 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).



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- (c) If necessary, for the purpose of achieving RVSM approval for a group of aircraft (see 8.3), 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 exceeds 37 m (120 ft) and/or the absolute value of mean ASE plus three standard deviations of ASE exceed 75 m (245 ft). When such a limitation is established, it should be identified in the data submitted to support the approval application, and documented in appropriate aircraft operating manuals. However, visual or aural warning/indication associated with such a limitation need not be provided in the aircraft.

6.3.5 Aircraft types for which an application for a Type Certificate or major change in type design is made after April 9, 1997, should meet the criteria established for the Basic envelope in the Full RVSM envelope.

6.3.6 The standard for aircraft submitted for approval as non-group aircraft, as defined in sub-paragraph 8.3.2, is as follows:

- a. for all conditions in the Basic RVSM envelope:

Residual static source error + worst case avionics < 160 ft (50 m))

- b. for all conditions in the Basic RVSM envelope:

Residual static source error + worst case avionics < 160 ft (50 m))

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.

6.4 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 nongust conditions.

Note: Aircraft types for which application for type certification or major change in type design is made on or before April 9, 1997 which are equipped with automatic altitude control systems with flight management system/performance management system inputs allowing variations up to ± 130 ft (± 40 m) under nonturbulent, nongust conditions do not require retrofit or design alteration.

7.0 AIRCRAFT SYSTEMS

7.1 Equipment for RVSM Operations

7.1.1 The minimum equipment fit is:

- (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;



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- 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 encoded 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 subparagraphs 6.3.3, 6.3.4 or 6.3.6, as appropriate; and
- e. Signals referenced to a pilot selected altitude for automatic control and alerting. These signals will need to be derived from an altitude measurement system meeting the criteria of this document, and, in all cases, enabling the criteria of subparagraphs 7.2.6 and 7.3 to be met.

7.1.2 One secondary surveillance radar transponder with an altitude reporting system that can be connected to the altitude measurement system in use for altitude keeping.

7.1.3 One operational Traffic Alert and Collision Avoidance System (TCAS) or Airborne Collision Avoidance System (ACAS) (Shall be in accordance with the applicable Foreign State Regulatory Requirements).

7.1.4 An altitude alerting system.

7.1.5 An automatic altitude control system.

7.2. **Altimetry**

7.2.1 **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.

7.2.2 **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.



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- 7.2.3 **Altimetry System Accuracy** The total system accuracy will need to satisfy the criteria of sub-paragraphs 6.3.3, 6.3.4 or 6.3.6 as appropriate.
- 7.2.4 **Static Source Error Correction** If the design and characteristics of the aircraft and its **altimetry** system are such that the criteria of subparagraphs 6.3.3, 6.3.4 or 6.3.6 are not satisfied by the location and geometry of the static sources alone, then suitable SSEC will need to be applied automatically within the avionics equipment of the altimetry system. The design aim for static source error correction, whether applied by aerodynamic/geometric means or within the avionics equipment, should be to produce a minimum residual static source error, but in all cases, it should lead to compliance with the criteria of sub-paragraphs 6.3.3, 6.3.4 or 6.3.6, as appropriate.
- 7.2.5 **Altitude Reporting Capability** The aircraft altimetry system will need to provide an output to the aircraft transponder.
- 7.2.6 **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 6.3.3, 6.3.4 or 6.3.6, 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.
- 7.2.7 **Altimetry System Integrity** the RVSM approval process will need to verify that the predicted rate of occurrence of 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.
- 7.3 **Altitude Alerting**
- The altitude deviation system will need to signal an alert when the altitude displayed to the flight crew deviates from selected altitude by more than a nominal threshold value. For aircraft for which an application for a Type Certificate is made before April 9, 1997, the nominal threshold value will need to be not greater than ± 90 m (± 300 ft). For aircraft for which an application for a Type Certificate is made on or after April 9, 1997, the value will need to be not greater than ± 60



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m (± 200 ft). The overall equipment tolerance in implementing these nominal values will need to be not greater than ± 15 m (± 50 ft).

7.4 Automatic Altitude Control System

7.4.1 As a minimum, a single automatic altitude control system should be installed which is capable of controlling aircraft height within a tolerance band of ± 65 ft (± 20 m) about the acquired altitude when the aircraft is operated in straight and level flight under nonturbulent, nongust conditions.

Note: Aircraft types for which application for Type Certification is on or before April 9, 1997, which are equipped with automatic altitude control system with flight management system/performance management system inputs which allow variations up to ± 130 ft (± 40 m) under nonturbulent, nongust conditions do not require retrofit or design alteration.

7.4.2 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.

7.5 System Limitations

7.5.1 The Aircraft Flight Manual should include a statement of compliance against this document quoting the applicable Service Bulletin or build standard of the aircraft. In addition, the following statement should be included: - "Airworthiness Approval alone does not authorize flight into airspace for which an RVSM Operational Approval is required by an ICAO Regional Navigation Agreement."

7.5.2 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.



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8.0 AIRWORTHINESS APPROVAL

8.1 General

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

8.1.2 For the first step:

- in the case of a newly built aircraft, the aircraft manufacturer develops and submits to the responsible authority of the state of manufacture, 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 Kuwait DGCA, 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.
- in the case of an aircraft already in service, the aircraft manufacturer (or an approved design organization), submits to a responsible authority, either in the state of manufacture or the state in which the aircraft is registered, the performance and analytical data that supports RVSM airworthiness approval of a defined build standard. The data will be supplemented with a Service Bulletin, 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. Approval by the Kuwait DGCA, and, where applicable, validation of that approval by other authorities, indicates acceptance of that aircraft type and build standard as complying with the RVSM airworthiness criteria.

8.1.3 The combination of performance and analytical data, Service Bulletin(s) or equivalent, continued airworthiness instructions, and the approved amendment or supplement to the Aircraft Flight Manual is known as the RVSM approval data package.

8.1.4 For the second step, an aircraft operator shall apply to the Kuwait DGCA, 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 Service Bulletins, 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 (see paragraph 7.5) has been incorporated. Approval by the Kuwait DGCA indicates



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that the aircraft is eligible for RVSM operations. The Kuwait DGCA will notify the designated monitoring cell accordingly.

NOTE: *For RVSM airspace for which an operational approval is prescribed, airworthiness approval alone does not authorize flight in that airspace.*

8.2 Contents of the RVSM Approval Data Package

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 8 and 9.
- (d) The procedures to be used to ensure that all aircraft submitted for airworthiness approval comply with RVSM criteria. These procedures will include the references of applicable Service Bulletins and the applicable approved Aircraft Flight Manual amendment or supplement.
- (e) The maintenance instructions that ensure continued airworthiness for RVSM approval.

The items listed in 8.2 are explained further in the following subparagraphs.

8.3 Aircraft Groupings

8.3.1 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 differences between the parent aircraft and the derivative aircraft.*

- (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 should comply with the manufacturer's same specification and have the same part number.



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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.

8.3.2 If an airframe does not meet the conditions of sub-paragraphs 8.3.1(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.

8.4 Flight Envelopes

The RVSM operational flight envelope, as defined in paragraph 6, is the Mach number, W/δ and altitude ranges over which an aircraft can be operated in cruising flight within the RVSM airspace. Appendix 1 gives an explanation of W/δ . The RVSM operational flight envelope for any aircraft may be divided into two parts as explained below:

8.4.1 **Full RVSM Flight Envelope** The Full envelope will comprise the entire range of operational Mach number, W/δ and altitude values over which the aircraft can be operated within RVSM airspace. Table 1 establishes the parameters to be considered.



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TABLE 1 - FULL RVSM ENVELOPE BOUNDARIES

	Lower Boundary is defined by	Upper boundary is defined by
Level	• FL 290	The lower of: • FL 410 • Aircraft maximum certified altitude • Altitude limited by: cruise thrust; buffet; other aircraft flight limitations
Mach	The lower of: • Maximum endurance (holding speed) • Manoeuvre speed	The lower of: • M_{mo}/V_{mo} • Speed limited by cruise thrust; buffet; other aircraft flight limitations
Gross Weight	• The lowest gross weight compatible with operations in RVSM airspace.	• The highest gross weight compatible with operations in RVSM airspace.

8.4.2 Basic RVSM Flight Planning Envelope The boundaries for the Basic envelope are the same as those for the Full envelope except for the upper Mach boundary.

8.4.3 For the Basic envelope, the upper Mach boundary may be limited to a range of airspeeds over which the aircraft group can reasonably be expected to operate most frequently. This boundary should be declared for each aircraft group by the aircraft manufacturer or the approved design organization. The boundary may be equal to the upper Mach/airspeed boundary defined for the Full envelope or a lower value. This lower value should not be less than the Long Range Cruise Mach Number plus 0.04 Mach, unless limited by available cruise thrust, buffet, or other flight limitations.

Note: Long Range Cruise Mach Number is the Mach for 99% of best fuel mileage at the particular W/δ under consideration.



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8.5 Performance Data

The data package should contain data sufficient to show compliance with the accuracy criteria set by paragraph 6.

8.5.1 **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 sub-paragraph 6.3.3 and 6.3.4. Each should be evaluated.

8.5.2 Where precision flight calibrations are used to quantify or verify altimetry system performance they may be accomplished by any of the following methods. Flight calibrations should be performed only when appropriate ground checks have been completed. Uncertainties in application of the method will need to be assessed and taken into account in the data package.

- (a) Precision tracking radar in conjunction with pressure calibration of atmosphere at test altitude.
- (b) Trailing cone.
- (c) Pacer aircraft.
- (d) Any other method acceptable to the Kuwait DGCA.

Note: When using pacer aircraft, the pacer aircraft will need to be calibrated directly to a known standard. It is not acceptable to calibrate a pacer aircraft by another pacer aircraft.

8.5.3 **Altimetry System Error Calculation** It is implicit in the intent of subparagraph 8.3, for group aircraft approvals and for non-group approvals, that a trade-off may be made between the various error sources which contribute to ASE. This document does not specify separate limits for the various error sources that contribute to the mean and variable components of ASE as long as the overall ASE accuracy criteria of sub-paragraph 6.3 are met. For example, in the case of an aircraft group approval, the smaller the mean of the group and the more stringent the avionics standard, the larger the available allowance for SSE variations. In all cases, the trade-off adopted should be presented in the data package in the form of an error calculation that includes all significant error sources. This is discussed in more detail in the following sections. Altimetry system error sources are discussed in Appendix 2.

8.5.4 **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 calculation when the equipment is operated in the environmental conditions expected to be met during RVSM operations.



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- 8.5.5 **Groups of Aircraft** Where approval is sought for an aircraft group, the associated data package will need to show that the criteria of subparagraph 8.3.3 and 8.3.4 are met. Because of the statistical nature of these criteria, the content of the data package may vary considerably from group to group.
- (a) The mean and airframe-to-airframe variability of ASE should be established, based on precision flight test calibration of a number of aircraft. Where analytical methods are available, it may be possible to enhance the flight test data base and to track subsequent changes in the mean and variability based on geometric inspections and bench test, or any other method acceptable to the Kuwait DGCA. In the case of derivative aircraft it may be possible to use data from the parent as part of the data base. This may be applicable to a fuselage stretch where the only difference in mean ASE between groups could be reliably accounted for by analytical means.
 - (b) An assessment of the aircraft-to-aircraft variability of each error source should be made. The error assessment may take various forms as appropriate to the nature and magnitude of the source and the type of data available. For example, for some error sources (especially small ones), it may be acceptable to use specification values to represent three standard deviations. For other error sources (especially larger ones) a more comprehensive assessment may be required. This is especially true for airframe error sources where specification values of ASE contribution may not have been previously established.
 - (c) In many cases, one or more of the major ASE error sources will be aerodynamic in nature, such as variations in the airframe surface contour in the vicinity of the static pressure source. If evaluation of these errors is based on geometric measurements, substantiation should be provided that the methodology used is adequate to ensure compliance. An example of the type of data that could be used to provide this substantiation is provided in Appendix 3, figure 3-2.
 - (d) An error calculation should be established to ensure that the criteria of sub-paragraphs 6.3.3 and 5.3.4 are met. As noted in 8.5.1, the worst condition experienced in flight may differ for each criterion and therefore the component error values may also differ.
 - (e) In showing compliance with the overall criteria, the component error sources should be combined appropriately. In most cases this will involve the algebraic summation of the mean components of the errors, root-sum-square (rss) combination of the variable components of the errors, and summation of the rss value with the absolute value of the overall mean. Care should be taken that only variable component error sources that are independent of each other are combined by rss.



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- (f) The methodology described above for group approval is statistical. This is the result of the statistical nature of the risk analysis and the resulting statements of Appendix 5 sub-paragraphs 5 (a) and 5 (b). In the context of a statistical method, the statements of Appendix 5, sub-paragraph 5 (c) need further explanation. This item states that 'each individual aircraft in the group shall be built to have an ASE contained within $\pm 60\text{m}$ ($\pm 200\text{ ft}$)'. This statement has not been taken to mean that every airframe should be calibrated with a trailing cone or equivalent to demonstrate that ASE is within $\pm 60\text{m}$ (200 ft). Such an interpretation would be unduly onerous considering that the risk analysis allows for a small proportion of aircraft to exceed 60m (200 ft). However, it is accepted that if any aircraft is identified as having an error exceeding $\pm 60\text{m}$ ($\pm 200\text{ ft}$) then it should receive corrective action.

8.5.6 Non-group Aircraft When an aircraft is submitted for approval as a nongroup aircraft, as explained in sub-paragraph 8.3.2, the data should be sufficient to show that the criteria of sub-paragraph 6.3.6 are met. The data package should specify how the ASE calculation has been allocated between residual SSE and avionics error. The operator and Kuwait DGCA should agree on what data is needed to satisfy approval criteria. The following data should be established:

- (a) Precision flight test calibration of the aircraft to establish its ASE or SSE over the RVSM envelope. Flight calibration should be performed at points in the flight envelope(s) as agreed by the Kuwait DGCA. One of the methods listed in sub-paragraphs 8.5.2 (a) to (d) should be used.
- (b) Calibration of the avionics used in the flight test as required to establish residual SSE. The number of test points should be agreed by the Kuwait DGCA. Since the purpose of the flight test is to determine the residual SSE, specially calibrated altimetry equipment may be used.
- (c) Specifications for the installed altimetry avionics equipment, identifying the largest allowable errors.
- (d) Using the foregoing, compliance with the criteria of sub-paragraph 6.3.6 should be demonstrated. If, subsequent to aircraft approval for RVSM operation, avionic units that are of a different manufacturer or part number are fitted, it should be demonstrated that the standard of avionic equipment provides equivalent altimetry system performance.



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8.6 Compliance Procedures

The data package will need to define the procedures, inspections and tests, and the limits that will be used to ensure that all aircraft approved against the data package 'conform to type'; that is all future approvals, whether of new build or in-service aircraft, meet the calculation allowances developed according to sub-paragraph 8.5.3. The calculation allowances will be established by the data package and include a methodology that allows for tracking the mean and standard deviation for new build aircraft. Limits will need to be defined for each potential source of error. A discussion of error sources is provided in Appendix 2. Examples of procedures are presented in Appendix 3. Where an operating limitation has been applied, the package should contain the data and information necessary to document and establish that limitation.

8.7 Continued Airworthiness

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

- (a) The Structural Repair Manual with special attention to the 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).

8.7.2 The data package should include details of any special procedures that are not covered in sub-paragraph 8.7.1, 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 Kuwait DGCA. 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.

8.8 Post Approval Modification

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



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9.0. CONTINUED AIRWORTHINESS (MAINTENANCE PROCEDURES)

9.1 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 program. 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.

9.2 Maintenance Programs

Each operator requesting RVSM operational approval should establish RVSM maintenance and inspection practices acceptable to, and as required by, the Kuwait DGCA, that include any required maintenance specified in the data package (sub-paragraph 8.2). Operators of aircraft subject to maintenance program approval will need to incorporate these practices in their maintenance program.

9.3 Maintenance Documents

The following items should be reviewed, as appropriate:

- (a) Maintenance Manuals.
- (b) Structural Repair Manuals.
- (c) Standard Practices Manuals.
- (d) Illustrated Parts Catalogues.
- (e) Maintenance Schedule.
- (f) MMEL & MEL

9.4 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 manufacturers' 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 manufacturers' maintenance instructions and the performance criteria of the RVSM approval data package.



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(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 Kuwait DGCA.

(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 Kuwait DGCA.

(d) Built-in Test Equipment (BITE) testing 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 Kuwait DGCA.

(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 program 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.

9.4.1 **Action for Non-compliant Aircraft** Those aircraft positively identified as exhibiting height keeping performance errors that require investigation, as discussed in subparagraph 10.7, should not be operated in RVSM airspace until the following actions have been taken:

(a) The failure or malfunction is confirmed and isolated; and,



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- (b) Corrective action is taken as necessary to comply with subparagraph 8.5.5
- (f) and verified to support RVSM approval.

9.4.2 **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.

9.4.3 **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 Kuwait DGCA.
- b. Test equipment should be calibrated at periodic intervals as agreed by the Kuwait DGCA using reference standards whose calibration is certified as being traceable to national standards acceptable to the Kuwait DGCA. The approved maintenance program should include an effective quality control program 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.

10.0 **OPERATIONAL APPROVAL**

10.1 **Purpose and Organization**

Paragraph 5 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. Appendices 4 and 5 are related to this paragraph and contain essential information for operational programs.

10.2 **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 Kuwait DGCA will need to be satisfied that:



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- a) each aircraft holds airworthiness approval according to paragraph 8;
- b) each operator has continued airworthiness programs (maintenance procedures) according to paragraph 9;
- c) where necessary, operating procedures unique to the airspace have been incorporated in operations manuals including any limitations identified in paragraph 7.5.
- d) high levels of aircraft height keeping performance can be maintained.

10.3 Content of Operator RVSM Application

The following material should be made available to the Kuwait DGCA, in sufficient time to permit evaluation, before the intended start of RVSM operations.

- (a) **Airworthiness Documents** Documentation that shows that the aircraft has RVSM airworthiness approval. This should include an Approved Flight Manual amendment or supplement.
- (b) **Description of Aircraft Equipment** A description of the aircraft appropriate to operations in an RVSM environment.
- (c) **Training Programs and Operating Practices and Procedures** Holders of Air Operators Certificates (AOC) shall submit a training syllabus for initial, and where appropriate, recurrent training programs together with other appropriate material to the Kuwait DGCA. 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.

Guidance on the content of training programs and operating practices and procedures is given in Appendix 4. 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) 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 Kuwait DGCA 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.



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- (g) **Maintenance** When application is made for operational approval, the operator should establish a maintenance program acceptable to the Kuwait DGCA, as detailed in paragraph 9.
- (h) **Plan for Participation in Verification/Monitoring Programs** The operator should establish a plan acceptable to the Kuwait DGCA, for participation in any applicable verification/ monitoring program (See 10.5). 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.

10.4 Form of Approval Documents

- (a) Approval to operate in designated RVSM airspace areas will be granted by an Approval issued by the Kuwait DGCA in accordance with KCASR's. Each aircraft group for which the operator is granted approval will be listed in the Approval.

10.5 Height Monitoring

The introduction and continued operation of 300 m (1,000 ft) RVSM separation is conditional upon the principal consideration that the risk of collision as a consequence of a loss of vertical separation, from any cause, is less than the agreed target level of safety. Accordingly, height monitoring is carried out using a system comprised of fixed ground based Height Monitoring Units (HMU) and a GPS-based monitoring system comprising portable GPS Monitoring Units (GMU), GPS reference stations, post-flight processing facilities and logistic support. Air Operators are required to have a number of their aircraft height monitored within six months of receiving RVSM approval. Information on the location of Height Monitoring Units can be found in ICAO Document 7030/4 – Regional Supplementary Procedures (for appropriate region)

10.6 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 Kuwait DGCA 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 Kuwait DGCA. 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).



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10.6.1 **Height keeping Errors** Height keeping errors fall into two broad categories:

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

10.6.2 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 error.*

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

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



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APPENDIX 1 - EXPLANATION OF W/δ

1. Sub-paragraph 8.4 describes the range of flight conditions over which conformity with the ASE criteria should be shown. The description includes reference to the parameter W/δ . The following discussion is provided for the benefit of readers who may not be familiar with the use of this parameter.

2. It would be difficult to show all of the gross weight, altitude, and speed conditions which constitute the RVSM envelope(s) on a single plot. This is because most of the speed boundaries of the envelopes are a function of both altitude and gross weight. As a result, a separate chart of altitude versus Mach would be required for each aircraft gross weight. Aircraft performance engineers commonly use the following technique to solve this problem.

3. For most jet transports the required flight envelope can be reduced to a single chart with good approximation, by the use of the parameter δ (weight divided by atmospheric pressure ratio). This fact is due to the relationship between W/δ and the fundamental aerodynamic variables M and lift coefficient as shown below.

$W/\delta = 1481.4 C_L M^2 S_{Ref}$, where:

δ = ambient pressure at flight altitude divided by sea level standard pressure of 1013.25 hPa

W/δ = Weight over Atmospheric Pressure Ratio

C_L = Lift Coefficient

M = Mach Number

S_{Ref} = Reference Wing Area

4. As a result, the RVSM flight envelope(s) may be reduced into one chart by simply plotting W/δ rather than altitude, versus Mach Number. Since δ is a fixed value for a given altitude, weight can be obtained for a given condition by simply multiplying the W/δ value by δ .

5. Over the RVSM altitude range, it is a good approximation to assume that position error is uniquely related to Mach Number and W/δ for a given aircraft.



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APPENDIX 2 - ALTIMETRY SYSTEM ERROR COMPONENTS

1.0 INTRODUCTION

Sub-paragraph 8.5.3 states that an error calculation should be established and presented in the approval data package. The error calculation is discussed in some detail in subsequent paragraphs for group and nongroup aircraft. The purpose of this appendix is to provide guidance to help ensure that all the potential error sources are identified and included in the error calculation for each particular model.

2.0 OBJECTIVE OF ASE CALCULATION

2.1 The purpose of the ASE calculation is to demonstrate that the allocation of tolerances amongst the various parts of the altimetry system is, for the particular data package, consistent with the overall statistical ASE criteria. These individual tolerances within the ASE calculation also form the basis of the procedures, defined in the airworthiness approval data package, which will be used to demonstrate that aircraft satisfy the RVSM criteria.

2.2 It is necessary to ensure that the calculation takes account of all contributory components of ASE.

2.3 For group approval it is necessary to ensure either that the calculation assesses the combined effect of the component errors in a way that is statistically realistic, or that the worst case specification values are used.

3.0 ALTIMETRY SYSTEM ERROR

3.1 Breakdown

Figure 2-1 shows the breakdown of total ASE into its main components, with each error block representing the error associated with one of the functions needed to generate a display of pressure altitude. This breakdown encompasses all altimetry system errors that can occur, although different system architectures may combine the components in slightly different ways.

- (a) The 'Actual Altitude' is the pressure altitude corresponding to the undisturbed ambient pressure.
- (b) 'Static Source Error' is the difference between the undisturbed ambient pressure and the pressure within the static port, at the input end of the static pressure line.
- (c) 'Static Line Error' is any difference in pressure along the length of the line.



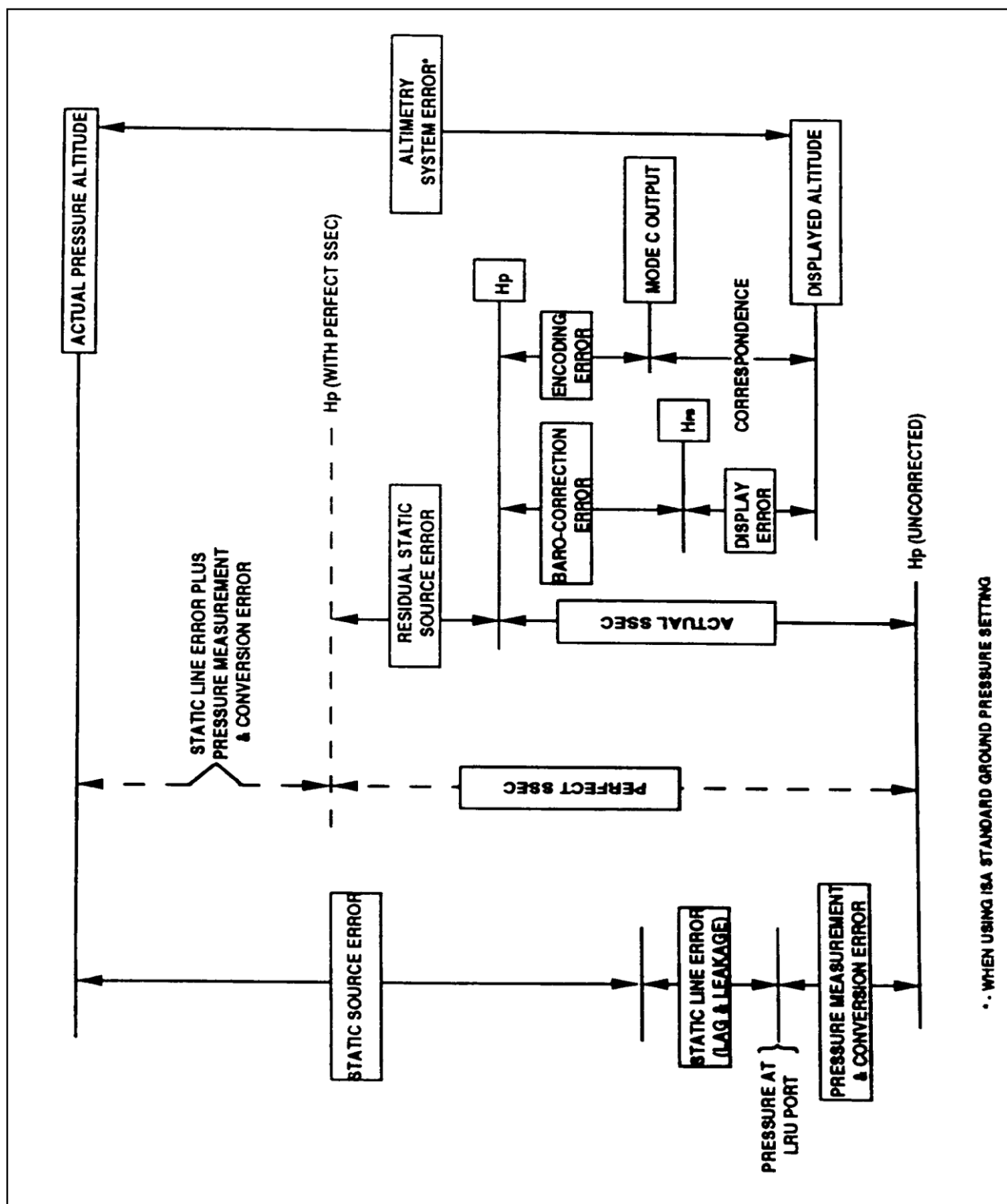
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- (d) 'Pressure Measurement and Conversion Error' is the error associated with the processes of sensing the pneumatic input seen by the avionics, and converting the resulting pressure signal into altitude. As drawn, Figure 2-1 represents a self-sensing altimeter system in which the pressure measurement and altitude conversion functions would not normally be separable. In an air data computer system, the two functions would be separate, and SSEC would probably then be applied before pressure altitude (H_p) was calculated.
- (e) 'Perfect SSEC' would be that correction that compensated exactly for the SSE actually present at any time. If such a correction could be applied, then the resulting value of H_p calculated by the system would differ from the actual altitude only by the static line error plus the pressure measurement and conversion error. In general, this cannot be achieved, so although the 'Actual SSEC' can be expected to reduce the effect of SSE, it will do so imperfectly.



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FIGURE 2-1 ALTIMETRY SYSTEM ERRORS





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- (f) Residual Static Source Error' is applicable only in systems applying an avionic SSEC. It is the difference between the SSE and the correction actually applied. The corrected value of H_p will therefore differ from actual pressure altitude by the sum of static line error, pressure measurement and conversion error, and residual SSE.
- (g) Between H_p and displayed altitude occur the baro-correction error and the display error. Figure 2-1 represents their sequence for a self-sensing altimeter system. Air data computer systems can implement baro-correction in a number of ways that would modify slightly this part of the block diagram, but the errors would still be associated with either the baro-correction function or the display function. The only exception is that those systems that can be switched to operate the display directly from the H_p signal can eliminate bar correction error where standard ground pressure setting is used, as in RVSM operations.

3.2 COMPONENTS

The altimetry system errors presented in Figure 2-1 and described in 4.1 are discussed below in greater detail.

3.2.1 **Static Source Error** The component parts of SSE are presented in Table 21, with the factors that control their magnitude.

- (a) The reference SSE is the best estimate of actual SSE, for a single aircraft or an aircraft group, obtained from flight calibration measurements. It is variable with operating condition characteristically reducing to a family of W/δ curves that are functions of Mach. It includes the effect of any aerodynamic compensation that may have been incorporated in the design. Once determined, the reference SSE is fixed for the single aircraft or group, although it may be revised when considering subsequent data.
- (b) The test techniques used to derive the reference SSE will have some measurement of uncertainty associated with them, even though known instrumentation errors will normally be eliminated from the data. For trailing-cone measurements the uncertainty arises from limitations on pressure measurement accuracy, calibration of the trailing-cone installation, and variability in installations where more than one are used. Once the reference SSE has been determined, the actual measurement error is fixed, but as it is unknown it can only be handled within the ASE calculation as an estimated uncertainty.
- (c) The airframe variability and probe/port variability components arise from differences between the individual airframe and probe/port, and the example(s) of airframe and probe port used to derive the reference SSE.

3.2.2 **Residual Static Source Error**

- (a) The components and factors are presented in Table 2-1. Residual SSE is made up of those error components which make actual SSE different from the reference value,



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components 2, 3, and 4 from Table 2-1, plus the amount by which the actual SSEC differs from the value that would correct the reference value exactly, components 2(a), (b) and (c) from Table 2-2.

- (b) There will generally be a difference between the SSEC that would exactly compensate the reference SSE, and the SSEC that the avionics is designed to apply. This arises from practical avionics design limitations. The resulting error component 2(a) will therefore be fixed, for a particular flight condition, for the single aircraft or group. Additional variable errors 2(b) and 2(c) arise from those factors that cause a particular set of avionics to apply an actual SSEC that differs from its design value.
- (c) The relationship between perfect SSEC, reference SSEC, design SSEC and actual SSEC is illustrated in Figure 2-2, for the case where static line errors and pressure measurements and conversion errors are taken as zero.
- (d) Factors that create variability of SSE relative to the reference characteristic should be accounted for twice. First, as noted for the SSE itself in Table 2-2, and secondly for its effect on the corruption of SSEC as in factor 2(a)(i) of Table 2-2. Similarly the static pressure measurement error should be accounted for in two separate ways. The main effect will be by way of the 'pressure measurement and conversion' component, but a secondary effect will be by way of factor 2(a)(ii) of Table 2-2.



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TABLE 2-1
STATIC SOURCE ERROR
(Cause: Aerodynamic disturbance to free-stream conditions)

Factors	Error Components
Airframe Effects Operating Condition (M, H_p, α, β) Geometry: shape of airframe location of static sources variations of surface contour near the sources variations in fit of nearby doors, skin panels or other items Probe/Port Effects Operating Condition (M, H_p, α, β) Geometry: shape of probe/port manufacturing variations installation variations	1) Reference SSE values from flight calibration measurements. 2) Uncertainty of flight calibration measurements. 3) Airframe to Airframe variability 4) Probe/Port to Probe/Port variability

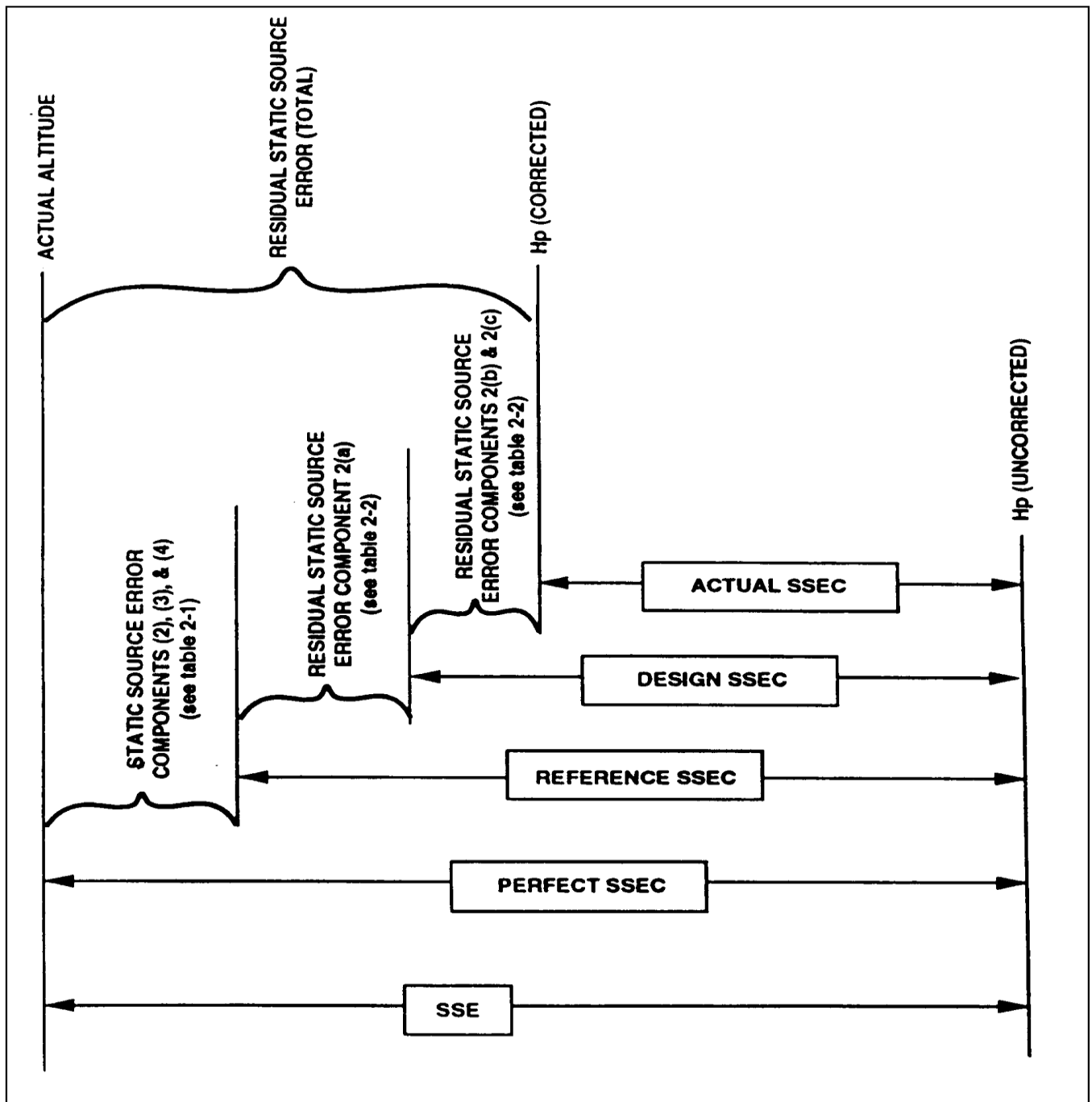
**TABLE 2-2 RESIDUAL STATIC ERROR (Aircraft with Avionic
SSEC) (Cause: Difference between the SSEC actually applied
and the actual SSE)**

Factors	Error Components
1) As for Static Source Error <u>PLUS</u> 2) Source of input data for SSEC function a) Where SSEC is a function of Mach: i) P_s sensing: difference in SSEC from reference SSE. ii) P_s measurement: pressure transduction error iii) P_T errors: mainly pressure transduction error b) Where SSEC is a function of Angle of Attack: i) geometric effects on α - sensor tolerances - installation tolerances - local surface variations ii) measurement error - angle transducer accuracy 3) Implementation of SSEC function a) Calculation of SSEC from input data b) Combination of SSEC with uncorrected height	1) Static Source Error Components (2), (3), and (4) from table 2-1 <u>PLUS</u> 2a) Approximation in fitting design SSEC to flight calibration reference SSE. 2b) Effect of production variability (sensors and avionics) on achieving design SSEC. 2c) Effect of operating environment (sensors and avionics) on achieving design SSEC.



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FIGURE 2-2 SSE/SSEC RELATIONSHIP FOR ASE WHERE STATIC LINE,
PRESSURE MEASUREMENT AND CONVERSION ERRORS ARE ZERO





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3.2.3 **Static Line Error** Static line errors arise from leaks and pneumatic lags. In level cruise these can be made negligible for a system that is correctly designed and correctly installed.

3.2.4 **Pressure Measurement and Conversion Error**

- (a) The functional elements are static pressure sensing, which may be mechanical, electromechanical or solid-state, and the conversion of pressure signal to pressure altitude.
- (b) The error components are:
 - (i) calibration uncertainty;
 - (ii) nominal design performance;
 - (iii) unit to unit manufacturing variations; and
 - (iv) effect of operating environment
- (c) The equipment specification is normally taken to cover the combined effect of the error components. If the value of pressure measurements and conversion error used in the error calculation is the worst-case specification value, then it is not necessary to assess the above components separately. However, calibration uncertainty, nominal design performance and effect of operating environment can all contribute to bias errors within the equipment tolerance. Therefore, if it is desired to take statistical account of the likely spread of errors within the tolerance band, then it will be necessary to assess their likely interaction for the particular hardware design under consideration.
- (d) It is particularly important to ensure that the specified environmental performance is adequate for the intended application.

3.2.5 **Baro-Setting Error** This is the difference between the value displayed and the value applied within the system. For RVSM operation the value displayed should always be the International Standard Atmosphere ground pressure, but setting mistakes, although part of TVE, are not components of ASE.

- (a) The components of Baro-Setting Error are:
 - (i) resolution of setting knob/display;
 - (ii) sensing of displayed value; and
 - (iii) application of sensed value.
- (b) The applicability of these factors and the way that they combine depend on the particular system architecture.



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- (c) For systems in which the display is remote from the pressure measurement function there may be elements of the sensing and/or application or sensed value error components which arise from the need to transmit and receive the setting between the two locations.

3.2.6 **Display Error** The cause is imperfect conversion from altitude signal to display.
The components are:

- (a) conversion of display input signal;
- (b) graticule/format accuracy, and
- (c) readability.

3.2.7 In self-sensing altimeters the first of these would normally be separate from the pressure measurement and conversion error.



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APPENDIX 3 - ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

1.0 INTRODUCTION

The data package is discussed in sub-paragraph 8.2. It is stated, in subparagraph 8.5.5 (c) that the methodology used to establish the static source error should be substantiated. It is further stated in sub-paragraph 8.6 that procedures be established to ensure conformity of newly manufactured aero planes. There may be many ways of satisfying these objectives; two examples are discussed below.

2.0 EXAMPLE 1

2.1 One process for showing compliance with RVSM criteria is shown in Figure 3-1. Figure 3-1 illustrates those flight test calibrations and geometric inspections will be performed on a given number of aircraft. The flight calibrations and inspections will continue until a correlation between the two is established. Geometric tolerances and SSEC will be established to satisfy RVSM criteria. For aircraft being manufactured, every Nth aircraft will be inspected in detail and every MTh aircraft will be flight test calibrated, where 'N' and 'M' are determined by the aircraft manufacturer and agreed to by the Kuwait DGCA. The data generated by 'N' inspections and 'M' flight calibrations can be used to track the mean and three standard deviation values to ensure continued compliance of the model with the criteria of paragraph 6. As additional data are acquired, they should be reviewed to determine if it is appropriate to change the values of N and M as indicated by the quality of the results obtained.

2.2 There are various ways in which the flight test and inspection data might be used to establish the correlation. The example shown in Figure 3-2 is a process in which each of the error sources for several aero planes is evaluated based on bench tests, inspections and analysis. Correlation between these evaluations and the actual flight test results would be used to substantiate the method.

2.3 The method illustrated in Figures 3-1 and 3-2 is appropriate for new models since it does not rely on any pre-existing data base for the group.

3.0 EXAMPLE 2

3.1 Figure 3- illustrates that flight test calibrations should be performed on a given number of aircraft and consistency rules for air data information between all concerned systems verified. Geometric tolerances and SSEC should be established to satisfy the criteria. A correlation should be established between the design tolerances and the consistency rules. For aircraft being manufactured, air data information for all aircraft should be



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checked for consistency in cruise conditions and every Mth aircraft should be calibrated, where M is determined by the manufacturer and agreed to by the Kuwait DGCA. The data generated by the M flight calibrations should be used to track the mean and three standard deviation values to ensure continued compliance of the group with the criteria of paragraph 6.



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APPENDIX 4 TRAINING PROGRAMS AND OPERATING PRACTICES AND PROCEDURES

1.0 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 3 to 7 of this appendix should be standardized and incorporated into training programs and operating practices and procedures. Certain items may already be adequately standardized 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.

2.0 FLIGHT PLANNING

During flight planning the flight crew, and if applicable Flight Dispatchers, 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. 0 PRE-FLIGHT PROCEDURES AT 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 authorized person other than the pilot (e.g. a flight engineer or ground engineer);
- (c) before takeoff, 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.



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

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

4.0 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) One secondary surveillance radar transponder with an altitude reporting system that can be connected to the altitude measuring equipment in use for altitude keeping.
- (e) Operational Traffic Alert and Collision Avoidance System (TCAS) or Airborne Collision Avoidance System (ACAS).

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;*

5.0 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 man oeuvres;



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- (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



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appropriate to the airspace concerned. Detailed guidance on contingency procedures are contained in the relevant publications dealing with the airspace. Refer to Appendix 4, 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.

6.0 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:

- (a) Primary and standby altimeter readings.
- (b) Altitude selector setting.
- (c) Subscale setting on altimeter.
- (d) Autopilot used to control the aero plane and any differences when an alternative autopilot 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) The transponder selected to provide altitude information to ATC and any difference noted when an alternative transponder was selected.



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7.0 SPECIAL EMPHASIS ITEMS: FLIGHT CREW TRAINING

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

- (a) knowledge and understanding of standard ATC phraseology used in each area of operations (see paragraph 9.0);
- (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 300m (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.

8.0 SPECIFIC REGIONAL OPERATIONAL PROCEDURES

8.1 The areas of applicability (by Flight Information Region) of RVSM airspace in identified ICAO regions is contained in the relevant sections of ICAO Document 7030/4. In addition these sections contain operational and contingency procedures unique to the regional airspace concerned, specific flight planning requirements, and the approval requirements for aircraft in the designated region.

8.2 For the North Atlantic Minimum Navigation Performance Specification (MNPS) airspace, where RVSM have been in operation since 1997, further guidance (principally for State Approval Agencies) is contained in ICAO Document NAT 001 T13/5NB.5 with



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comprehensive operational guidance (aimed specifically at aircraft operators) in the North Atlantic MNPS Airspace Operational Manual.

- 8.3 Comprehensive guidance on operational matters for European RVSM Airspace is contained in EUROCONTROL Document ASM ET1.ST.5000 entitled “The ATC Manual for a Reduced Vertical Separation (RVSM) in Europe” with further material included in the relevant State Aeronautical Publications.
- 8.4 During the life of this document, it is expected that additional ICAO regions or parts of regions may introduce RVSM into their airspace. For example, plans are well in hand to introduce RVSM into parts of the Pacific region. The area of applicability and associated procedures will be published in Document 7030/4 where reference will be made to additional material as necessary.



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APPENDIX 5 - REVIEW OF ICAO DOCUMENT 9574 - HEIGHT KEEPING PARAMETERS

- 1.0 ICAO Document 9574 Manual on the implementation of a 300m (1,000 ft) Vertical Separation Minimum Between FL 290-FL 410 Inclusive, covers the overall analysis of factors for achieving an acceptable level of safety in a given airspace system. The major factors are passing frequency, lateral navigation accuracy, and vertical overlap probability. Vertical overlap probability is a consequence of errors in adhering accurately to the assigned flight level, and this is the only factor covered in this document.
- 2.0 In ICAO Doc. 9574, Section 2.1.1.3, the vertical overlap probability requirement is restated as the aggregate of height keeping errors of individual aircraft that must lie within the total vertical error (TVE) distribution, expressed as the simultaneous satisfaction of the following four criteria:
- (a) “ the proportion of height keeping errors beyond 90 m (300 ft) in magnitude must be less than 2.0×10^{-3} ; and
 - (b) the proportion of height keeping errors beyond 150 m (500 ft) in magnitude must be less than 3.5×10^{-6} ; and
 - (c) the proportion of height keeping errors beyond 200 m (650 ft) in magnitude must be less than 1.6×10^{-7} ; and
 - (d) the proportion of height keeping errors between 290 m (950 ft) and 320 m (1,050 ft) in magnitude must be less than 1.7×10^{-8} .”
- 3.0 The following characteristics presented in ICAO Doc. 9574 were developed in accordance with the conclusions of ICAO Doc. 9536. They are applicable statistically to individual groups of nominally identical aircraft operating in the airspace. These characteristics describe the performance that the groups need to be capable of achieving in service, exclusive of human factors errors and extreme environmental influences, if the airspace system TVE criteria are to be satisfied. The following characteristics are the basis for development of this document:
- (a) The mean altimetry system error (ASE) of the group shall not exceed $\pm 25\text{m}$ ($\pm 80\text{ ft}$); and
 - (b) The sum of the absolute value of the mean ASE for the group and three standard deviations of ASE within the group shall not exceed 75 m (245 ft); and
 - (c) Errors in altitude keeping shall be symmetric about a mean of 0 m (0 ft) and shall have a standard deviation not greater than 13 m (43 ft) and should be such that the error frequency decreases with increasing error magnitude at a rate which is at least exponential.



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- 4.0 ICAO Doc. 9574 recognizes that specialist study groups would develop the detailed specifications, to ensure that the TVE objectives can be met over the full operational envelope in RVSM airspace for each aircraft group. In determining the breakdown of tolerances between the elements of the system it was considered necessary to set system tolerances at levels that recognize that the overall objectives must be met operationally by aircraft and equipment subject to normal production variability, including that of the airframe static source error, and normal in-service degradation. It was also recognized that it would be necessary to develop specifications and procedures covering the means for ensuring that Inservice degradation is controlled at an acceptable level.
- 5.0 On the basis of studies reported in ICAO Doc. 9536, Volume 2, ICAO Doc. 9574 recommended that the required margin between operational performance and design capability should be achieved by ensuring that the performance criteria are developed to fulfil the following, where the narrower tolerance in sub-paragraph 5 (b) is specifically intended to allow for some degradation with increasing age:
- (a) 'the mean uncorrected residual position error (static source error) of the group shall not exceed ± 25 m (± 80 ft); and
 - (b) the sum of the absolute value of the mean ASE for the group and three standard deviations of ASE within the group, shall not exceed 60 m (200 ft); and
 - (c) each individual aircraft in the group shall be built to have ASE contained within ± 60 m (± 200 ft); and
 - (d) an automatic altitude control system shall be required and will be capable of controlling altitude within a tolerance band of ± 15 m (± 50 ft) about selected altitude when operated in the altitude hold mode in straight and level flight under non-turbulent, non-gust conditions.'
- 6.0 These standards provide the basis for the separate performance aspects of airframe, altimetry, altimetry equipment and automatic altitude control system. It is important to recognize that the limits are based on studies (Doc. 9536, Volume 2), which show that ASE tends to follow a normal distribution about a characteristic mean value for the aircraft group and that the in-service performances of the separate groups aggregate together to give an overall performance spread which is distributed about the population mean TVE that is nominally zero. Consequently, controls should be provided which will preclude the possibility that individual aircraft approvals could create clusters operating with a mean significantly beyond 25m (80 ft) in magnitude, such as could arise where elements of the altimetry system generate bias errors additional to the mean corrected static source error.



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APPENDIX 6 – SPECIFIC PROCEDURES FOR THE NORTH ATLANTIC

1.0 Introduction

- 1.1 The following requirements will be applied when RVSM criteria is being applied in North Atlantic Minimum Navigation Performance Specification (NAT MNPS) airspace. This standard can be applied in other areas where RVSM criteria is applied. It is anticipated that regional authorities will develop similar guidance when planning for RVSM implementation in additional oceanic/remote areas or continental airspace.
- 1.2 This appendix contains procedures that are unique to North Atlantic RVSM airspace. Contingency procedures contained in regional supplementary procedures and guidance specifically related to RVSM are presented in this appendix. Contingencies which relate to lateral as well as vertical navigation are discussed.

2.0 General Information: Airspace Dimensions

- 2.1 Where RVSM is implemented in NAT MNPS airspace, NAT MNPS approval will encompass demonstration of special qualification for both lateral and height-keeping performance.
- 2.2 NAT MNPS airspace has a ceiling of FL 420 and a floor of FL 285 with 1,000 feet (300 m) vertical separation applied between aircraft operating at and between FL 290 and FL 410.

3.0 Intended Use of this Information

- 3.1 Section 4, Basic Concepts for Contingencies is intended to provide an overview of contingency procedures. It is intended to orient the pilot's thinking to the concepts involved and aid in understanding the specific guidance detailed in Sections 5 and 6. This information should be included in training programs and appropriate flight crew manuals.
- 3.2 Section 5, Guidance to the Pilot in the Event of Equipment Failures or Encounter with Turbulence After Entering NAT MNPS Airspace details guidance on specific actions for the pilot to take in the situations listed. The pilot actions should be considered required pilot knowledge and should be included in training/qualification programs and appropriate flight crew manuals.
- 3.3 Section 6, Reprint of ICAO Document 7030, North Atlantic Contingency Procedures. In this section, North Atlantic Regional Supplementary Procedures (Doc. 7030), paragraph 5.0, Special Procedures for In-Flight Contingencies (applicable) when RVSM is implemented) are printed for ease of reference. Doc. 7030 paragraph 5.0 details guidance on specific



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pilot actions to be taken. Pilot actions should be considered required pilot knowledge. The information may be condensed for ease of presentation and should be included in training/qualification programs and appropriate flight crew manuals.

3.4 Sections 7 discusses RVSM transition areas and Section 8 is a general discussion of pilot action in relation to the proposed RVSM monitoring system. These Sections should be included in training/qualification programs and appropriate flight crew manuals.

3.5 Section 9 Expanded RVSM Equipment Failure and Turbulence Scenarios reviews the situations discussed in Section 5 in greater detail. The information may be used in training programs as an Air Operator deems appropriate.

4.0 Basic Concepts for Contingencies

4.1 The NAT Regional Supplementary Procedures document (DOC. 7030) provides for RVSM implementation in NAT MNPS Airspace. Specifically, paragraph 5.0 addresses RVSM operations.

4.2 The basic concepts for contingencies described in this Section have been developed from the specific guidance contained in Doc. 7030, paragraph 5.0 and paragraph 5 of this Attachment. Contingency procedures are complicated when specific situations are detailed. However, if the details are examined in context of certain basic concepts, then they are more easily understood. Reviewing these concepts should serve to aid pilot's understanding of the specific contingency procedures detailed in Doc. 7030 and section 5 of this Attachment.

4.3 The basic concepts for contingencies are:

- (1). Guidance for contingency procedures should not be interpreted in any way which prejudices the final authority and responsibility of the pilot in command for the safe operation of the aircraft.
- (2). If the pilot is unsure of the vertical or lateral position of the aircraft or the aircraft deviates from its assigned altitude or track for cause without prior ATC clearance, then the pilot must take action to mitigate the potential for collision with aircraft on adjacent routes or flight levels.
 - i) in this situation, the pilot should alert adjacent aircraft by making maximum use of the aircraft light and broadcasting position, flight level, and intentions on 121.5 MHz (or 131.8 MHz as a back-up).
- (3) Unless the nature of the contingency dictates otherwise, the pilot should advise ATC as soon as possible of a contingency situation and if possible, request an ATC clearance before deviating from the assigned route or flight level.



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- (4) If a revised ATC clearance cannot be obtained in a timely manner and action is required to avoid potential conflict with other aircraft, then the aircraft should be flown at an altitude and/or on a track where other aircraft are least likely to be encountered:
- (i) This can be accomplished by offsetting from routes or altitudes normally flown in the airspace. The Doc 7030 paragraphs entitled “Special Procedures for In-flight Contingencies” provide recommendations on the order of preference for the following pilot actions:
- (A) The pilot may offset half the lateral distance between routes or tracks.
- (B) The pilot may offset half the vertical distance between altitudes normally flown.
- (C) The pilot may also consider descending below FL 285 or climbing above FL 410. (The vast majority of oceanic traffic has been found to operate between FL 290 and 410. Flight above FL 410 or below FL 285 may limit exposure to conflict with other aircraft).
- (5) When executing a contingency maneuver, the pilot should:
- (i) Watch for conflicting traffic both visually and by reference to ACAS, if equipped.
- (ii) Continue to alert other aircraft using 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used) and aircraft lights.
- (iii) Continue to fly offset tracks or altitudes until an ATC clearance is obtained.
- (iv) Obtain an ATC clearance as soon as possible.

5.0 Guidance to the Pilot (Including Expected ATC Actions) In the Event of Equipment Failures or Encounters with Turbulence After Entry Into NAT MNPS Airspace.

5.1 Emergency Conditions

In addition to emergency conditions that require immediate descent, such as loss of thrust or pressurization, ATC should be made aware of the less explicit conditions that may make it impossible for an aircraft to maintain its cleared flight level appropriate to RVSM. Controllers should react to such conditions but these actions cannot be specified, as they will be dynamically affected by real-time situation.



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5.2 Objective of the Guidance Information

5.2.1 The following information is provided with the purpose of giving the pilot guidance on actions to be taken under certain conditions of equipment failures and encounters with turbulence. It also describes the expected ATC controller actions in these situations. It is recognized that the pilot and controller will use judgement to determine the action most appropriate to any given situation. The guidance information recognizes that for certain equipment failures, the safest course of action may be for the aircraft to maintain the assigned flight level and route while the pilot and controller take precautionary action to protect separation. For extreme cases of equipment failure, however, the guidance recognizes that the safest course of action may be for the aircraft to leave MNPS airspace by obtaining a revised ATC clearance or if unable to obtain prior ATC clearance, executing the established Doc. 7030 contingency maneuver to leave the assigned route or track.

5.3 Contingency Scenarios

The following paragraphs summarize pilot actions to mitigate the potential for conflict with other aircraft in certain contingency situations. They should be reviewed in conjunction with the expanded contingency scenarios detailed in paragraph 6.0, which contain additional technical and operational detail.



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SCENARIO 1

The pilot is:

Unsure of the Vertical Position of the Aircraft Due to Loss or Degradation of All Primary Altimetry Systems, or

Unsure of the Capability to Maintain Cleared Flight Level Due to Turbulence or Loss of All Automatic Altitude Control Systems

The Pilot Should	ATC Can Be Expected To
Maintain Cleared Flight Level while evaluating the situation.	
Watch for conflicting aircraft both visually and by reference to TCAS/ACAS.	
If considered necessary, alert nearby aircraft by: 1) making maximum use of exterior lights; 2) broadcasting position, flight level, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot-air-to-air frequency may be used).	
Notify ATC of the situation and intended course of action. Possible courses of action include:	Obtain the pilot's intentions and pass essential traffic information.
1) Maintaining the cleared flight level and route if ATC can provide lateral, longitudinal or conventional vertical separation.	1) If the pilot intends to continue in RVSM airspace, assess traffic situation to determine if the aircraft can be accommodated through the provisions of lateral, longitudinal or conventional vertical separation, and if so, apply the appropriate minimum.



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2) Requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft is cannot maintain cleared flight level and ATC cannot establish adequate separation from other aircraft.	2) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.
3) Executing the DOC. 7030 contingency maneuver to offset from the assigned track and flight level, if prior ATC clearance cannot be obtained and the aircraft cannot maintain cleared flight level.	3) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, advise the pilot of essential traffic information, notify other aircraft in the vicinity and continue to monitor the situation.
	Notify adjoining ATC facilities/sectors of the situation.

SCENARIO 2

There is a Failure or Loss of Accuracy of One Primary Altimetry System (e.g. Greater Than 200 feet Difference Between Primary Altimeters)

The Pilot Should

Cross check standby altimeter, confirm the accuracy of a primary altimeter system and notify ATC of the loss of redundancy. If unable to confirm primary altimeter accuracy, follow pilot actions listed in the preceding scenario.

6.0 Expanded Equipment Failure and Turbulence Encounter Scenarios



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SCENARIO 1

All Automatic Altitude Control Systems Fail (e.g. Automatic Altitude Hold)

The Pilot Should	ATC Can Be Expected To
Initially:	
Maintain cleared flight level.	
Evaluate the aircraft's capability to maintain altitude through manual control.	
Subsequently:	
Watch for conflicting traffic by visually and by reference to TCAS/ACAS.	
If considered necessary, alert nearby aircraft by: 1) Making maximum use of exterior lights; 2) Broadcasting position, flight level, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot-air-to-air frequency may be used).	
Notify ATC of the failure and intended course of action. Possible courses of action include:	
1) Maintaining the cleared flight level and route, if the aircraft can maintain level.	1) If the pilot intends to continue in RVSM airspace, assess traffic situation to determine if the aircraft can be accommodated through the provisions of lateral, longitudinal or conventional vertical separation, and if so, apply the appropriate minimum.
Requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft is cannot maintain cleared flight level and ATC cannot establish lateral, longitudinal or conventional vertical separation	2) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.
3) Executing the DOC. 7030 contingency maneuver to offset from the assigned track and flight level, if prior ATC clearance cannot be obtained and the aircraft cannot maintain cleared flight level.	3) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, advise the pilot of essential traffic information, notify other aircraft in the vicinity and continue to monitor the situation.
	Notify adjoining ATC facilities/sectors of the situation.



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SCENARIO 2

Loss of Redundancy in Primary Altimetry System

The Pilot Should	ATC Can Be Expected To
If the remaining Altimetry System is functioning normally, couple that system to the automatic altitude control system, notify ATC of the loss of redundancy and maintain vigilance of altitude keeping.	Acknowledge the situation and continue to monitor progress.

SCENARIO 3

All Primary Altimetry Systems are Considered Unreliable or Fail

The Pilot Should	ATC Can Be Expected To
Maintain cleared flight level by reference to the standby altimeter.	
Alert nearby aircraft by: 1) making maximum use of exterior lights; 2) broadcasting position, flight level, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot-airto-air frequency may be used).	
Consider declaring an emergency. Notify ATC of the failure and intended course of action. Possible courses of action include:	Obtain pilot's intentions, and pass essential traffic information.



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1) Maintaining cleared flight level and route if ATC can provide lateral, longitudinal or conventional vertical separation.	If the pilot intends to continue in RVSM airspace, assess traffic situation to determine if the aircraft can be accommodated through the provisions of lateral, longitudinal or conventional vertical separation, and if so,
	apply the appropriate minimum.
2) Requesting ATC clearance to climb above or descend below RVSM airspace if ATC cannot establish adequate separation from other aircraft.	2) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.
3) Executing the Doc. 7030 contingency maneuver to offset from the assigned track and flight level, if ATC clearance cannot be obtained.	3) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, advise the pilot of essential traffic information, notify other aircraft in the vicinity and continue to monitor the situation.
	Notify adjoining ATC facilities/sectors of the situation.

SCENARIO 4

The Primary Altimeters Diverge More Than 200 feet (60 m).

The Pilot Should

Attempt to determine the defective system and through established troubleshooting procedures and/or comparing the primary altimeter displays to the standby altimeter (as corrected by the correction cards).



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If the defective system can be determined, couple the functioning altimeter system to the altitude-keeping device.

If the defective system cannot be determined, follow the guidance in Scenario 3 for All Primary Altimetry Systems are Considered Unreliable or Fail.

SCENARIO 5

Turbulence (Greater Than Moderate) Which the Pilot Believes will Affect the Aircraft's Capability to Maintain Flight Level

The Pilot Should	ATC Can Be Expected To
Watch for conflicting traffic both visually and by reference to TCAS/ACAS.	
If considered necessary, alert nearby aircraft by: 1) making maximum use of exterior lights; 2) broadcasting position, flight level, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot-airto-air frequency may be used).	
Notify ATC of the failure and intended course of action. Possible courses of action include:	
1) Maintaining the cleared flight level and route if ATC can provide lateral, longitudinal or conventional vertical separation.	Assess traffic situation to determine if the aircraft can be accommodated, through the provision of lateral, longitudinal, or conventional separation, and if so, apply the minimum.
2) Requesting a flight level change, if necessary.	2) If unable to provide adequate separation, advise the pilot of essential traffic information and request pilot's intentions.



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3) Executing the Doc. 7030 contingency maneuver to offset from assigned track and flight level, if ATC clearance cannot be obtained and the aircraft cannot maintain cleared flight level.	3) Notify other aircraft in the vicinity and monitor the situation.
	Notify adjoining ATC facilities/sectors of situation.

7.0 Special Procedures For In-Flight Contingencies Published For Individual ICAO Regions in DOC. 7030.

Document 7030 should be considered the source document for specific contingency procedures applicable to individual ICAO regions. Doc. 7030 should always be consulted before training material or manuals are developed.

In-flight contingency procedures applicable to Pacific Oceanic operations are published in paragraph 4.0 of the Regional Supplementary Procedures for the Pacific and the Middle East/Asia (Mid/Asia)

In-flight contingency procedures applicable to the NAT Oceanic operations are published in paragraph 5.0 of NAT Regional Supplementary Procedures.

8.0 Wake Turbulence Procedures

The ATS authorities developed pilot ATC procedures for aircraft experiencing wake turbulence.

These procedures provide for the contingency use of a 2.0 NM lateral offset to avoid exposure to wake turbulence. The procedures have been published in State NOTAMS and Aeronautical Information Publications and are planned for publication in Regional Supplementary Procedures. These procedures should be incorporated in pilot training programs and manuals.

9.0 Transponder Failure and RVSM Transition Areas

The specific actions that ATC will take in case of transponder failure in RVSM areas will be determined by the provider States. Transition areas are planned to be established between airspace where different vertical separation standards are applied.



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APPENDIX 7 – PACIFIC OCEANIC RVSM AIRSPACE

Pacific Oceanic RVSM airspace is planned to be implemented in the Pacific Oceanic Flight Information Regions (FIRs) between FL 290 and FL 390 inclusive. NOTAM's and State Aeronautical Information Publications (AIP's) shall be consulted for current implementation plans and schedule.

