APPENDIX E - JAA Temporary Guidance Leaflet – 6

LEAFLET NO 6: GUIDANCE MATERIAL ON THE APPROVAL OF AIRCRAFT AND OPERATORS FOR FLIGHT IN AIRSPACE ABOVE FLIGHT LEVEL 290 WHERE A 300M (1,000 FT) VERTICAL SEPARATION MINIMUM IS APPLIED

This Temporary Guidance Leaflet No. 6 cancels and supersedes JAA Information Leaflet No. 23, dated April 1994. The leaflet provides guidance material for the approval of aircraft and operations in airspace where the vertical separation minimum above FL 290 is 300m (1,000 ft) (RVSM Operations).

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PREAMBLE

In 1994, the original version of this text was adopted as JAA Interim Policy and published in JAA Information Leaflet No. 23. The intention is to include this information in a proposed new JAA publication containing interpretative and explanatory material with acceptable means of compliance applicable to aircraft in general. The new publication is not yet established, therefore, the information, now revised, is being published in this Temporary Guidance Leaflet.

The revised material of this leaflet is derived directly from IL 23. The material has been updated to reflect the current status of RVSM operations in general, and to add guidance concerning the application of RVSM within designated airspace in the EUR region (referred to as European RVSM airspace) as defined in ICAO Doc 7030. The opportunity has been taken also to make a number of editorial corrections and clarifications of the original text. These revisions include:

- updates to the Background section;
- addition of a list of abbreviations;
- where appropriate, substitution of the mandatory terms "shall" and "must" with "should" consistent with the document's status as guidance material. Where criteria is stated reflecting mandatory requirements of ICAO or other regulatory material, the expression "will need to" is used;
- adoption of the generic term "responsible authority" to replace the various terms previously used to denote the organisations or persons, empowered under national laws, to be responsible for airworthiness certification, operational or maintenance approvals;
- substitution of the previously used terms "acquired altitude" and "commanded altitude" with the term "selected altitude" to represent the altitude/flight level the aircraft is required to keep irrespective of the method used by the pilot to select it;
- deletion of text which is no longer relevant;
- clarification and expansion of the guidance material dealing with the RVSM approval procedure;
- re-numbering of some paragraphs to improve the logical structure;

- introduction of a new material applicable to the European RVSM airspace in Appendix 6.

The units of measurement now used in this document are in accordance with the International System of Units (SI) specified in Annex 5 to the Convention on International Civil Aviation. Non-SI units are shown in parentheses following the base units. Where two sets of units are quoted, it should not be assumed that the pairs of values are equal and interchangeable. It may be inferred, however, that an equivalent level of safety is achieved when either set of units is used exclusively.

Since these revisions do not alter the basic technical criteria, previously established for RVSM approvals, revision marks have been omitted from this first issue of TGL No. 6.

It is not intended that aircraft which have received airworthiness approval in compliance with JAA Information Leaflet No. 23, or the equivalent FAA Interim Guidelines 91-RVSM, should be re-investigated. It is accepted that these aircraft satisfy the airworthiness criteria of this TGL No. 6.

1. PURPOSE

This document provides a Minimum Aircraft Systems Performance Specification (MASPS) for altimetry to support the use of a 300m (1,000 ft) vertical separation above FL 290. It establishes an acceptable means, but not the only means, that can be used in the approval of aircraft and operators to conduct flights in airspace or on routes where Reduced Vertical Separation Minimum (RVSM) is applied. The document contains guidance on airworthiness, continued airworthiness, and operational practices and procedures for RVSM airspace. RVSM airspace is any airspace or route between FL 290 and FL 410 inclusive where aircraft are separated vertically by 300m (1,000 ft).

2. RELATED REGULATIONS

National regulations relating to the granting of an Air Operator's Certificate (AOC), approval for flight in RVSM airspace, testing and inspection of altimeter systems, and maintenance procedures.

Note: National Regulations will be replaced by the appropriate JARs, when implemented. The following regulations are included in JAR OPS 1 for Commercial Air Transportation:

JAR-OPS 1.240	Routes and Areas of Operation.
JAR-OPS 1.241	Operations in Defined Airspace with RVSM.
JAR-OPS 1.872	Equipment for Operations in Defined Airspace with RVSM.

3. RELATED READING MATERIAL

International Civil Aviation Organisation (ICAO) Document 9574, Manual on the Implementation of a 300m (1,000 ft) Vertical Separation Minimum Between FL 290 - FL 410 Inclusive.

ICAO Document 9572, RGCSP, Seventh Meeting, Montreal 30 October - 20 November 1990.

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

ICAO Document 7030, Regional Supplementary Procedures- European Region.

EUROCONTROL Manual on Operational ATC Aspects in European RVSM airspace .

4. BACKGROUND

4.1 In 1982, under the overall guidance of the ICAO Review of the General Concept of Separation Panel (RGCSP), several States initiated a series of comprehensive work programmes to examine the feasibility of reducing the vertical separation minimum above FL 290 from 600m (2,000 ft) to 300m (1,000 ft). Studies were made by member states of EUROCONTROL (France, Germany, the Kingdom of the Netherlands, and the United Kingdom - in an extensive co-operative venture which was co-ordinated by the EUROCONTROL Agency), Canada, Japan, the former Union of the Soviet Socialist Republics (USSR), and the United States of America (USA).

4.2 The primary objectives of these studies was to decide whether a global implementation of the Reduced Vertical Separation Minimum (RVSM) :

a) would satisfy predetermined safety standards;
b) would be technically and operationally feasible, and
c) would provide a positive Benefit to Cost ratio.

4.3 These studies employed quantitative methods of risk assessment to support operational decisions concerning the feasibility of reducing the vertical separation minimum. The risk assessment consisted of two elements. First, risk estimation which concerns the development and use of methods and techniques with which the actual level of risk of an activity can be estimated; and second, risk evaluation which concerns the level of risk considered to be the maximum tolerable value for a safe system. The level of risk that is deemed acceptable is termed the Target Level of Safety (TLS). The basis of the process of risk estimation was the determination of the accuracy of height keeping performance of the aircraft population operating at/above FL 290. This was achieved through the use of high precision radar to determine the actual geometric height of aircraft in straight and level flight. This height was then compared with the geometric height of the flight level to which the aircraft had been assigned to determine the total vertical error (TVE) of the aircraft in question. Given this knowledge, it was possible to estimate the risk of collision solely as a consequence of vertical navigation errors of aircraft to which procedural vertical separation had been correctly applied. The RGCSP then employed an assessment TLS (2.5×10^{-9} fatal accidents per aircraft flight hour) to assess the technical feasibility of a 300m (1,000 ft) vertical separation minimum above FL 290 and also for developing aircraft height keeping capability requirements for operating with a 300m (1,000 ft) vertical separation minimum.

4.4 Using the assessment TLS of 2.5×10^{-9} fatal accidents per aircraft flight hour, the RGCSP concluded that a 300 m (1,000 ft) vertical separation minimum above FL 290 was technically feasible without imposing unreasonably demanding technical requirements on the equipment and that it would provide significant benefits in terms of economy and en-route airspace capacity. The technical feasibility referred to the fundamental capability of aircraft height keeping systems, which could be built, maintained, and operated in such a way that the expected, or typical, height keeping performance would be consistent with the safe implementation and use of a 300 m (1,000 ft) vertical separation minimum above FL 290. In reaching this conclusion on technical feasibility, the panel identified the need to establish:

(a) airworthiness performance requirements in the form of a comprehensive Minimum Aircraft Systems Performance Specification (MASPS) for all aircraft which would be operated in RVSM airspace;

(b) new operational procedures; and

(c) a comprehensive means of monitoring for safe operation.

4.5 In the USA, RTCA Special Committee SC 150 was established with the purpose of developing minimum system performance requirements, identifying required aircraft equipment improvements and operational procedure changes and assessing the impact of RVSM implementation on the aviation community. SC 150 served as the focal point for the study and development of RVSM criteria and programmes in the US from 1982 to 1987.

4.6 In Europe, EUROCAE Working Group WG 30 was established in 1987 to prepare an altimetry specification appropriate for 300m (1,000 ft) vertical separation above FL 290. Draft specification documents produced in WG-30 formed a major input to the technical documentation on altimetry requirements developed by the ICAO North Atlantic System Planning Group/Vertical Studies Implementation Group.

4.7 The second major report published by RGCSP on RVSM was the Report of RGCSP/7 (Montreal, 30 October - 20 November 1990). This report provided the draft "Manual on Implementation of a 300m (1,000 ft) Vertical Separation Minimum (VSM) Between FL 290 and 410 Inclusive". This material was approved by the ICAO Air Navigation Commission in February 1991 and published as ICAO Document 9574.

4.8 ICAO Doc 9574 provides guidance on RVSM implementation planning, airworthiness requirements, flight crew procedures, ATC considerations and system performance monitoring. This material was the basis of two MASPS documents which were issued for the application of RVSM in the Minimum Navigation Performance Specification (MNPS) Airspace of the North Atlantic (NAT) Region :

(a) JAA Information Leaflet No. 23: "Interim Guidance Material On The Approval Of Operators/ Aircraft For RVSM Operations", and

(b) FAA Document 91-RVSM: "Interim Guidance for Approval of Operations/ Aircraft for RVSM Operations".

Note: This Temporary Guidance Leaflet No. 6 replaces JAA Information Leaflet No. 23.

4.9 Appendix 5 provides a discussion of certain major conclusions detailed in Doc. 9574 which have served as the foundation for the development of the specific aircraft and operator approval criteria.

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

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.

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

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

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

Abbreviation	Meaning
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	Organised 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

6. THE APPROVAL PROCESS

6.1 General

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

6.2 Approval of Aircraft

6.2.1 Each aircraft type that an operator intends to use in RVSM airspace should have received RVSM airworthiness approval from the responsible authority, in accordance with paragraph 9, prior to approval being granted for RVSM operations, including the approval of continued airworthiness programmes. Paragraph 9 provides guidance for the approval of newly built aircraft and for aircraft that have already entered service. Paragraph 10 contains guidance on the continued airworthiness (maintenance and repair) programmes for all RVSM operations.

6.2.2 It is accepted that aircraft which have been approved in compliance with JAA Information Leaflet No. 23 or FAA Interim Guidelines 91-RVSM satisfy the airworthiness criteria of this TGL No. 6.

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

6.3 Operational Approval

For certain airspace, as defined by ICAO Regional Navigation Agreements, operators are required to hold State approval to operate in that airspace, which may or may not include RVSM. Paragraph 11 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 responsible authority.

7. RVSM PERFORMANCE

7.1 General

The objectives set out by the RGCSP have been translated into airworthiness standards by assessment of the characteristics of altimetry system error (ASE) and automatic altitude control.

7.2 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 5 and explained in 9.4. For the Full envelope, a larger ASE is allowed.

7.3 Altimetry System Error

7.3.1 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 equipment.

(c) Airframe to airframe variability of static source error.

(d) Effect of flight operating conditions on static source error.

7.3.2 Assessment of ASE, whether based on measured or predicted data will need to consider sub-paragraphs (a) to (d) of 7.3.1. 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.

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

(a) At the point in the envelope where the mean ASE reaches its largest absolute value that value should not exceed 25 m (80 ft);

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

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

(a) At the worst point in the Full envelope where the mean ASE reaches its largest absolute value, the absolute value should not exceed 37 m (120 ft).

(b) At the point in the Full envelope where the mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 75 m (245 ft).

(c) If necessary, for the purpose of achieving RVSM approval for a group of aircraft (see 9.3), 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.

7.3.5 Aircraft types for which an application for type certification is made after 1 January 1997, should meet the criteria established for the Basic envelope in the Full RVSM envelope.

7.3.6 The standard for aircraft submitted for approval as non-group aircraft, as defined in sub-paragraph 9.3.2, is as follows:

(a) For all conditions in the Basic envelope:
- | Residual static source error + worst case avionics | ≤ 50 m (160 ft)

(b) For all conditions in the Full envelope:
- | Residual static source error + worst case avionics | ≤ 60 m (200 ft)

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

7.4 Altitude Keeping

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

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

8. AIRCRAFT SYSTEMS

8.1 Equipment for RVSM Operations

The minimum equipment fit is:

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

(a) Cross-coupled static source/system, with ice protection if located in areas subject to ice accretion;

(b) Equipment for measuring static pressure sensed by the static source, converting it to pressure altitude and displaying the pressure altitude to the flight crew:

(c) Equipment for providing a digitally 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 sub-paragraphs 7.3.3, 7.3.4 or 7.3.7, 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 sub-paragraphs 8.2.6 and 8.3 to be met.

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

8.1.3 An altitude alerting system.

8.1.4 An automatic altitude control system.

8.2. Altimetry

8.2.1 *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.

8.2.2 *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.

8.2.3 *Altimetry System Accuracy* The total system accuracy will need to satisfy the criteria of sub-paragraphs 7.3.3, 7.3.4 or 7.3.7, as appropriate.

8.2.4 *Static Source Error Correction* If the design and characteristics of the aircraft and its altimetry system are such that the criteria of sub-paragraphs 7.3.3, 7.3.4 or 7.3.7 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 7.3.3, 7.3.4 or 7.3.7, as appropriate.

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

8.2.6 *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 7.3.3, 7.3.4 or 7.3.7, 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.

8.2.7 *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.

8.3 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 1 January 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 1 January 1997, the value will need to be not greater than ±60 m (±200 ft). The overall equipment tolerance in implementing these nominal values will need to be not greater than ±15 m (±50 ft).

8.4 Automatic Altitude Control System

8.4.1 As a minimum, a single automatic altitude control system with an altitude keeping performance complying with sub-paragraph 7.4, will need to be installed.

8.4.2 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.

9. AIRWORTHINESS APPROVAL

9.1 General

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

9.1.2 For the first step:

- in the case of a newly built aircraft, the aircraft constructor 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 responsible authority, and, where applicable, validation of that approval by other authorities, indicates acceptance of newly built aircraft, conforming to that type and build standard, as complying with the RVSM airworthiness criteria.
- in the case of an aircraft already in service, the aircraft constructor (or an approved design organisation), submits to the 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 responsible authority, 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.

9.1.3 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.

9.1.4 For the second step, an aircraft operator may apply to the responsible authority of the state in which the aircraft is registered, 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 has been incorporated. Approval by the authority indicates that the aircraft is eligible for RVSM operations. The authority will notify the designated monitoring cell accordingly.

For RVSM airspace for which an operational approval is prescribed, airworthiness approval alone does not authorise flight in that airspace.

9.2 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 7 and 8.

(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.

These items are explained further in the following sub-paragraphs.

9.3 Aircraft Groupings

9.3.1 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 minimise 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 of sub-paragraph 8.1 should comply with the manufacturer's same specification and have the same part number.

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

9.3.2 If an airframe does not meet the conditions of sub-paragraphs 9.3.1(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.

9.4 Flight Envelopes

The RVSM operational flight envelope, as defined in paragraph 5, 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:

9.4.1 *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.

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 or Speed	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

9.4.2 *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.

9.4.3 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 constructor or the approved design organisation. 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.

9.5 Performance Data

The data package should contain data sufficient to show compliance with the accuracy criteria set by paragraph 7.

9.5.1 *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 7.3.3 and 7.3.4. Each should be evaluated.

9.5.2 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 responsible authority.

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.

9.5.3 *Altimetry System Error Budget* It is implicit in the intent of sub-paragraph 7.3, 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 7.3 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 budget 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.

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

9.5.5 *Groups of Aircraft* Where approval is sought for an aircraft group, the associated data package will need to show that the criteria of sub-paragraph 7.3.3 and 7.3.4 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 responsible authority. 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 budget should be established to ensure that the criteria of sub-paragraphs 7.3.3 and 7.3.4 are met. As noted in 9.5.1, 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.

(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 ±60m (±200 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 ±60m (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 ±60m (±200 ft) then it should receive corrective action.

9.5.6 *Non-group Aircraft* When an aircraft is submitted for approval as a non-group aircraft, as explained in sub-paragraph 9.3.2, the data should be sufficient to show that the criteria of sub-paragraph 7.3.7 are met. The data package should specify how the ASE budget has been allocated between residual SSE and avionics error. The operator and responsible authority 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 responsible authority. One of the methods listed in sub-paragraphs 9.5.2 (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 responsible authority. 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.

Using the foregoing, compliance with the criteria of sub-paragraph 7.3.7 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.

9.6 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 budget allowances developed according to sub-paragraph 9.5.3. The budget 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.

9.7 Continued Airworthiness

9.7.1 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).

9.7.2 The data package should include details of any special procedures that are not covered in sub-paragraph 9.7.1, 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 responsible authority. However, alleviation of the flight test requirement may be given if it can be demonstrated that the relationship between any subsequent airframe/system degradation and its effects on altimetry system accuracy is understood and that it can be compensated or corrected.

(b) In-flight defect reporting procedures should be defined to aid identification of altimetry system error sources. Such procedures could cover acceptable differences between primary and alternate static sources, and others as appropriate.

(c) For groups of aircraft where approval is based on geometric inspection, there may be a need for periodic re-inspection, and the interval required should be specified.

9.8 Post Approval Modification

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

10. CONTINUED AIRWORTHINESS (MAINTENANCE PROCEDURES)

10.1 General

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

(b) Adequate maintenance facilities will need to be available to enable compliance with the RVSM maintenance procedures.

10.2 Maintenance Programmes

Each operator requesting RVSM operational approval should establish, RVSM maintenance and inspection practices, acceptable to, and as required by the responsible authority, that include any required maintenance specified in the data package (sub-paragraph 9.2). Operators of aircraft subject to maintenance programme approval will need to incorporate these practices in their maintenance programme.

10.3 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.

10.4 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.

(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 responsible authority.

(c) Any repairs, not covered by approved maintenance documents, that may affect the integrity of the continuing RVSM approval, e.g. those affecting the alignment of pitot/static probes, repairs to dents or deformation around static plates, should be subject to a design review acceptable to the responsible authority.

(d) Built-in Test Equipment (BITE) testing should not be used for system calibration unless it is shown to be acceptable by the aircraft constructor or an approved design organisation, and with the agreement of the responsible authority.

(e) An appropriate system leak check (or visual inspection where permitted) should be accomplished following reconnection of a quick-disconnect static line.

(f) Airframe and static systems should be maintained in accordance with the aircraft constructor'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 constructor, to ensure adherence to RVSM tolerances. These checks should be performed following repairs, or alterations having an effect on airframe surface and airflow.

(h) The maintenance and inspection programme for the autopilot will need to ensure continued accuracy and integrity of the automatic altitude control system to meet the height keeping standards for RVSM operations. This requirement will typically be satisfied with equipment inspections and serviceability checks.

(i) Whenever the performance of installed equipment has been demonstrated to be satisfactory for RVSM approval, the associated maintenance practices should be verified to be consistent with continued RVSM approval. Examples of equipment to be considered are:

  (i) Altitude alerting.

  (ii) Automatic altitude control system.

  (iii) Secondary surveillance radar altitude reporting equipment.

  (iv) Altimetry systems.

10.4.1 *Action for Non-compliant Aircraft* Those aircraft positively identified as exhibiting height keeping performance errors that require investigation, as discussed in sub-paragraph 11.7, should not be operated in RVSM airspace until the following actions have been taken:

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

(b) Corrective action is carried out as required to comply with sub-paragraph 9.5.5 (f) and verified to support RVSM approval.

10.4.2 *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.

10.4.3 *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 responsible authority.

(b) Test equipment should be calibrated at periodic intervals as agreed by the responsible authority using reference standards whose calibration is certified as being traceable to national standards acceptable to that authority. The approved maintenance programme should include an effective quality control programme with attention to the following:

(i) Definition of required test equipment accuracy.

(ii) Regular calibrations of test equipment traceable to a master standard. Determination of the calibration interval should be a function of the stability of the test equipment. The calibration interval should be established using historical data so that degradation is small in relation to the required accuracy.

(iii) Regular audits of calibration facilities both in-house and outside.

(iv) Adherence to approved maintenance practices.

(v) Procedures for controlling operator errors and unusual environmental conditions which may affect calibration accuracy.

11. OPERATIONAL APPROVAL

11.1 Purpose and Organisation

Paragraph 6 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 programmes.

11.2 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 responsible authority will need to be satisfied that

(a) each aircraft holds airworthiness approval according to paragraph 9;
(b) each operator has continued airworthiness programmes (maintenance procedures) according to paragraph 10;
(c) where necessary, operating procedures unique to the airspace have been incorporated in operations manuals (see Appendices 6 and 7);
(d) high levels of aircraft height keeping performance can be maintained.

11.3 Content of Operator RVSM Application

The following material should be made available to the responsible authority, 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.

(b) *Description of Aircraft Equipment* A description of the aircraft equipment appropriate to operations in an RVSM environment.

(c) *Training Programmes and Operating Practices and Procedures* Holders of Air Operators Certificates (AOC) may need to submit training syllabi for initial, and where appropriate, recurrent training programmes together with other appropriate material to the responsible authority. The material will need to show that the operating practices, procedures and training items, related to RVSM operations in airspace that requires State operational approval, are incorporated. Non-AOC operators will need to comply with local procedures to satisfy the responsible authority that their knowledge of RVSM operating practices and procedures is equivalent to that set for AOC Holders, sufficient to permit them to conduct RVSM operations. Guidance on the content of training programmes and operating practices and procedures is given in Appendix 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. Appendix 6 presents procedures used within airspace of the EUR region as defined in Doc 7030. Appendix 7 presents procedures that are unique to North Atlantic airspace for which specific State operational approval is required as stated in Doc 7030.

(d) *Operations Manuals and Checklists* The appropriate manuals and checklists should be revised to include information/guidance on standard operating procedures as detailed in Appendix 4. Manuals should include a statement of the airspeeds, altitudes and weights considered in RVSM aircraft approval; including identification of any operating limitations or conditions established for that aircraft group. Manuals and checklists may need to be submitted for review by the authority as part of the application process.

(e) *Past Performance* Relevant operating history, where available, should be included in the application. The applicant should show that changes needed in training, operating or maintenance practices to improve poor height keeping performance, have been made.

(f) *Minimum Equipment List* Where applicable, a minimum equipment list (MEL), adapted from the master minimum equipment list (MMEL) and relevant operational regulations, should include items pertinent to operating in RVSM airspace.

(g) *Maintenance* When application is made for operational approval, the operator should establish a maintenance programme acceptable to the responsible authority, as detailed in paragraph 10.

(h) *Plan for Participation in Verification/Monitoring Programmes* The operator should establish a plan acceptable to the responsible authority, for participation in any applicable verification/ monitoring programme (See 11.6). This plan will need to include, as a minimum, a check on a sample of the operator's fleet by an independent height monitoring system.

11.4 Demonstration Flight(s)

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

11.5 Form of Approval Documents

(a) *Holders of an Air Operator's Certificate* Approval to operate in designated RVSM airspace areas will be granted by an Approval issued by the responsible authority in accordance with JAR OPS 1, or in compliance with national legislation where State operational approval is required by an ICAO Regional Agreement. Each aircraft group for which the operator is granted approval will be listed in the Approval.

(b) *Non AOC Holders* These operators will be issued with an Approval as required by national regulations or with JAR OPS 2 when this JAR is published. These approvals will be valid for a period specified in national regulations, typically 2 years, and may require renewal.
Note: Subject to compliance with applicable criteria, an RVSM Approval combining the airworthiness approval of sub-paragraph 9.1.4 and the operational approval of paragraph 11.2 may be available from some authorities.

11.6 Airspace Verification/Monitoring Programmes

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

11.7 Suspension or Revocation 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 responsible authority within 72 hours. The report should include an initial analysis of causal factors and measures taken to prevent repeat occurrences. The need for follow up reports will be determined by the responsible authority. Occurrences that should be reported and investigated are errors of:

(a) TVE equal to or greater than ±90 m (±300 ft),

(b) ASE equal to or greater than ±75 m (±245 ft), and

(c) Assigned altitude deviation equal to or greater than ±90 m (±300 ft).

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

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

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

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

11.7.3 *Operators Actions* The operator should make an effective, timely response to each height keeping error. The responsible authority may consider suspending or revoking RVSM approval if the operator response to a height keeping error is not effective or timely. The responsible authority will consider the operator's past performance record in determining the action to be taken. If an operator shows a history of operational and/or airworthiness errors, then approval may be suspended until the root causes of these errors are shown to have been eliminated and that the operator's RVSM programmes and procedures are effective.

APPENDIX 1 - EXPLANATION OF W/δ

1 Sub-paragraph 9.4 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 collapsed to a single chart with good approximation, by the use of the parameter W/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 collapsed 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.

APPENDIX 2 - ALTIMETRY SYSTEM ERROR COMPONENTS

1. INTRODUCTION

Sub-paragraph 9.5.3 states that an error budget should be established and presented in the approval data package. The error budget is discussed in some detail in subsequent paragraphs for group and non-group 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 budget for each particular model.

2. OBJECTIVE OF ASE BUDGET

2.1 The purpose of the ASE budget 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 budget 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 budget takes account of all contributory components of ASE.

2.3 For group approval it is necessary to ensure either that the budget 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. 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.

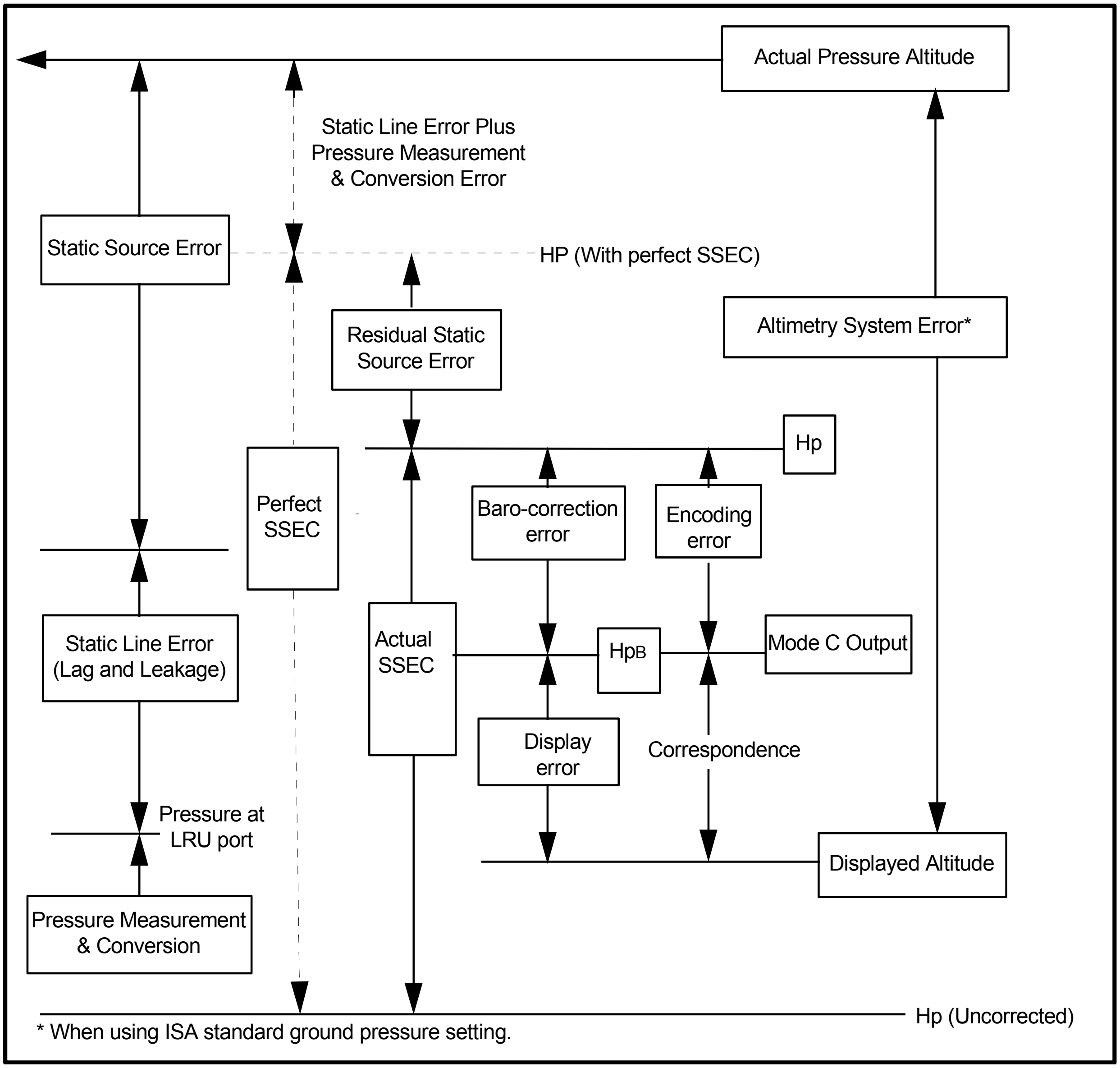
(d) 'Pressure Measurement and Conversion Error' is the error associated with the processes of sensing the pneumatic input seen by the avionics, and converting the resulting pressure signal into altitude. As drawn, Figure 2-1 represents a self-sensing altimeter system in which the pressure measurement 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 (Hp) 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 Hp 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.

(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 Hp will therefore differ from actual pressure altitude by the sum of static line error, pressure measurement and conversion error, and residual SSE.

(g) Between Hp and displayed altitude occur the baro-correction error and the display error. Figure 2-l 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 Hp signal can eliminate baro-correction error where standard ground pressure setting is used, as in RVSM operations.

FIGURE 2-1 ALTIMETRY SYSTEM ERRORS



3.2 Components

The altimetry system errors presented in Figure 2-1 and described in 3.1 are discussed below in greater detail.

3.2.1 *Static Source Error* The component parts of SSE are presented in Table 2-1, 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 budget 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, 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.

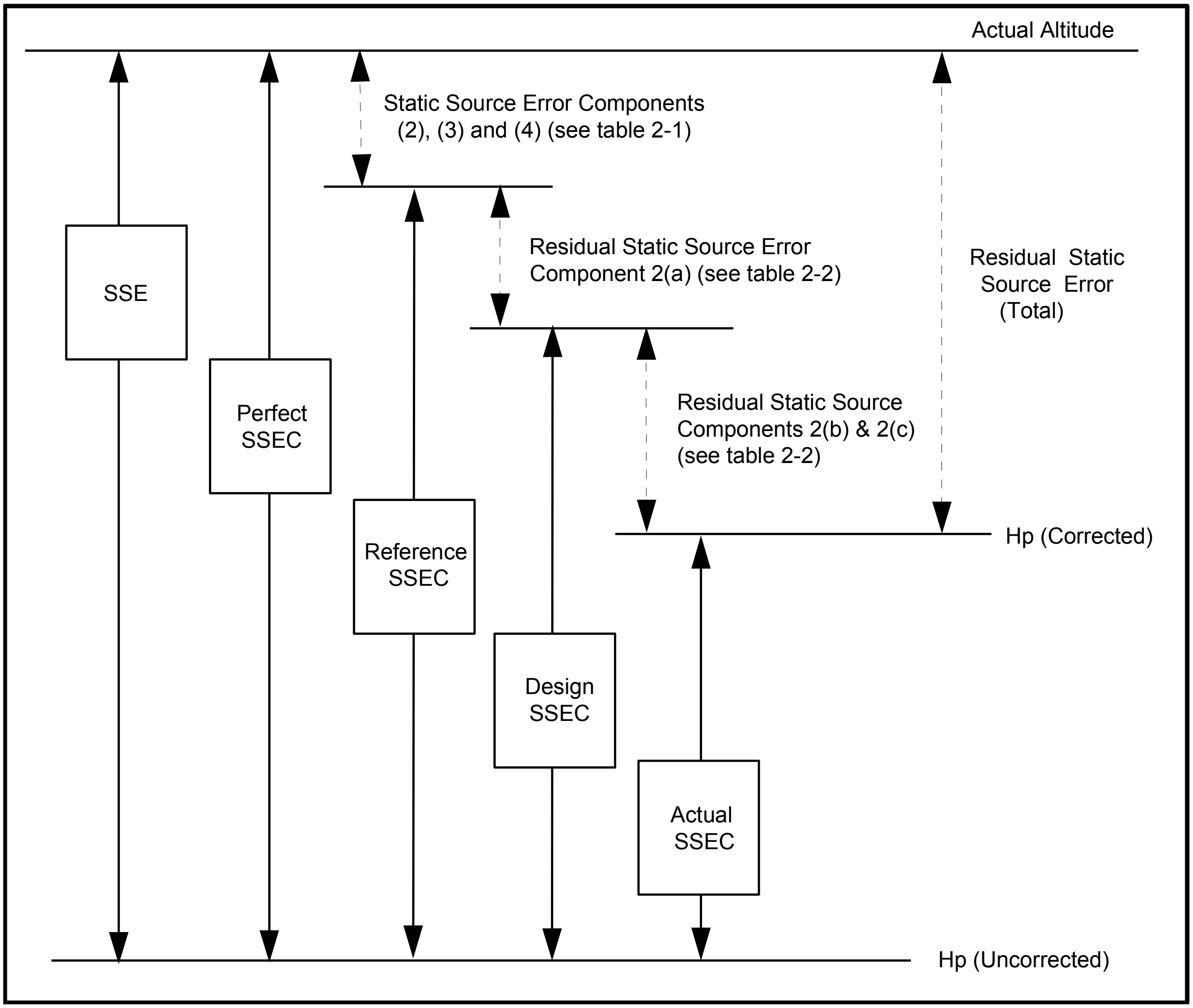
TABLE 2-1 STATIC SOURCE ERROR
(Cause: Aerodynamic Disturbance to Free-Stream Conditions)

Factors	Error Components
Airframe Effects Operating Condition (Speed, altitude, angle of attack, sideslip) Geometry: Size and 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.	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.
Probe/Port Effects Operating Condition (Speed, altitude, angle of attack, sideslip) Geometry: Shape of probe/port; Manufacturing variations; Installation variations.	

TABLE 2-2 RESIDUAL STATIC SOURCE 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 PLUS (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 alpha: -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) Error Components (*2*), (*3*), and (*4*) from table 2-1 PLUS 2(a) Approximation in fitting design SSEC to flight calibration reference SSE. 2(b) Effect of production variability (sensors and avionics) on achieving design SSEC. 2(c) Effect of operating environment (sensors and avionics) on achieving design SSEC.

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



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 budget 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.

(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.

APPENDIX 3 - ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

1. INTRODUCTION

The data package is discussed in sub-paragraph 9.2. It is stated, in sub-paragraph 9.5.5 (c) that the methodology used to establish the static source error should be substantiated. It is further stated in sub-paragraph 9.6 that procedures be established to ensure conformity of newly manufactured aeroplanes. There may be many ways of satisfying these objectives; two examples are discussed below.

2. 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 constructor and agreed to by the responsible authority. 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 7. 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 aeroplanes 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. EXAMPLE 2

3.1 Figure 3-3 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 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 responsible authority. 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 7.

FIGURE 3-1 PROCESS FOR SHOWING INITIAL AND CONTINUED COMPLIANCE OF AIRFRAME STATIC PRESSURE SYSTEMS

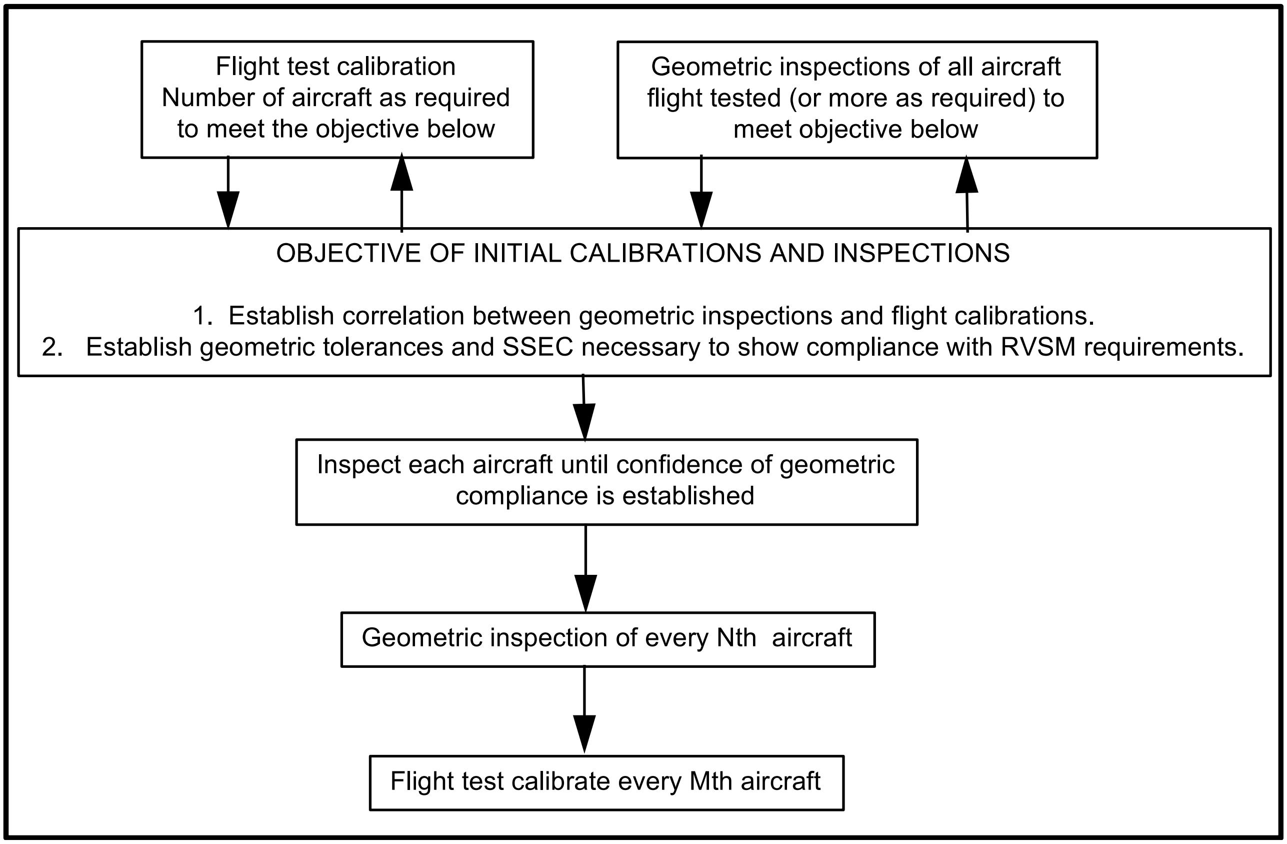


FIGURE 3-2 COMPLIANCE DEMONSTRATION GROUND - TO FLIGHT TEST CORRELATION PROCESS EXAMPLE

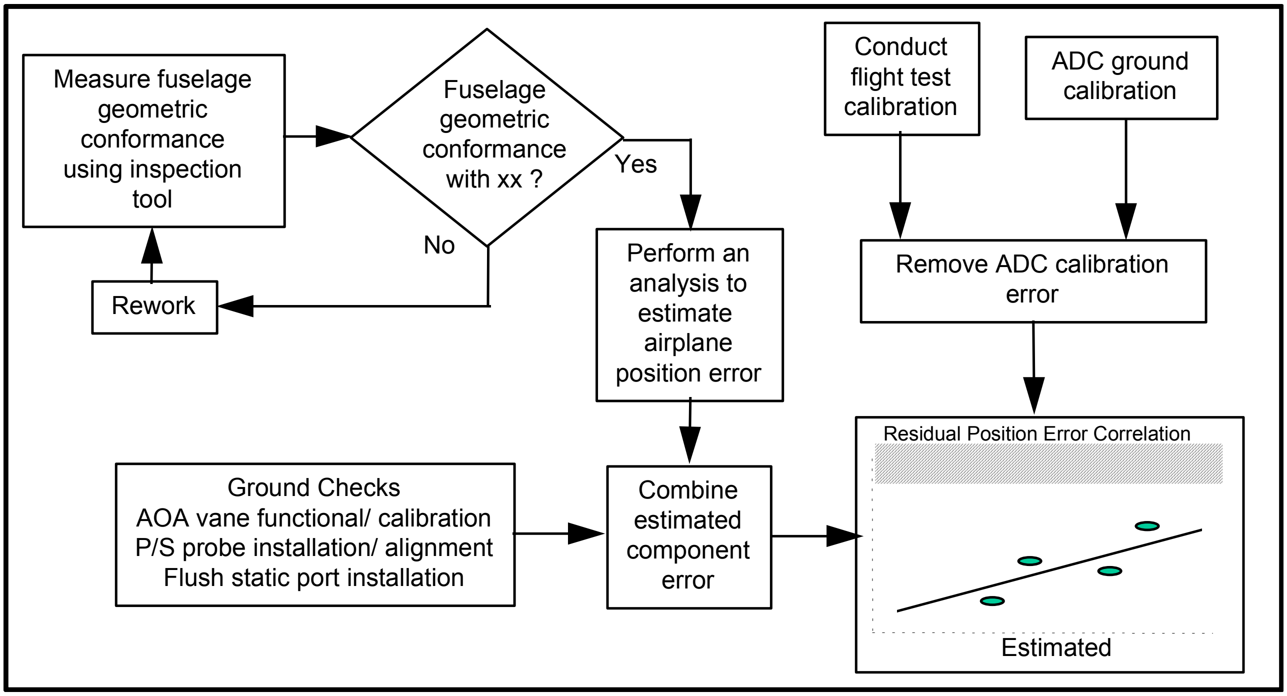
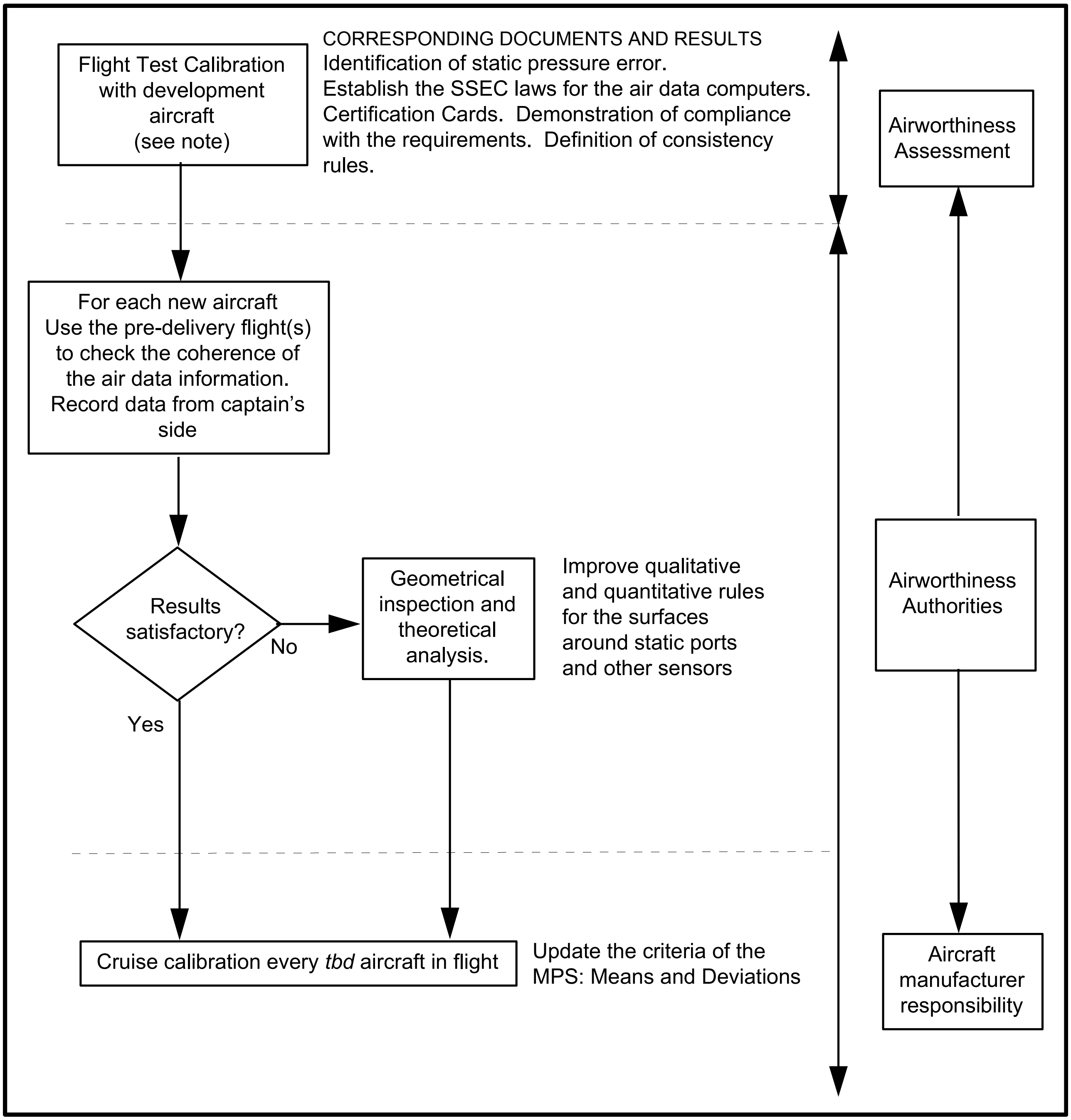


FIGURE 3-3 PROCESS FOR SHOWING INITIAL AND CONTINUED COMPLIANCE OF AIRFRAME STATIC PRESSURE SYSTEMS FOR NEW MODEL AIRCRAFT.



Note : The flight test installation chosen to get the calibration data will need to have an accuracy compatible with the level of performance to be demonstrated and an analysis of this accuracy will need to be provided. Any possible degradation of this accuracy will need to be monitored and corrected during the flight test period.

APPENDIX 4 TRAINING PROGRAMMES AND OPERATING PRACTICES AND PROCEDURES

1. INTRODUCTION

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

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

2. FLIGHT PLANNING

During flight planning the flight crew should pay particular attention to conditions that may affect operation in RVSM airspace.

These include, but may not be limited to:

(a) verifying that the airframe is approved for RVSM operations;

(b) reported and forecast weather on the route of flight;

(c) minimum equipment requirements pertaining to height keeping and alerting systems; and

(d) any airframe or operating restriction related to RVSM approval.

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

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

(a) review technical logs and forms to determine the condition of equipment required for flight in the RVSM airspace. Ensure that maintenance action has been taken to correct defects to required equipment;

(b) during the external inspection of aircraft, particular attention should be paid to the condition of static sources and the condition of the fuselage skin near each static source and any other component that affects altimetry system accuracy. This check may be accomplished by a qualified and authorised person other than the pilot (e.g. a flight engineer or ground engineer);

(c) before 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.

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. PROCEDURES PRIOR TO RVSM AIRSPACE ENTRY

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

(a) Two primary altitude measurement systems.

(b) One automatic altitude-control system.

(c) One altitude-alerting device.

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

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

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

5. IN-FLIGHT PROCEDURES

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

(a) Flight crews will need to comply with any aircraft operating restrictions, if required for the specific aircraft group, e.g. limits on indicated Mach number, given in the RVSM airworthiness approval.

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

(c) In level cruise it is essential that the aircraft is flown at the cleared flight level. This requires that particular care is taken to ensure that ATC clearances are fully understood and followed. The aircraft should not intentionally depart from cleared flight level without a positive clearance from ATC unless the crew are conducting contingency or emergency manoeuvres;

(d) When changing levels, the aircraft should not be allowed to overshoot or undershoot the cleared flight level by more than 45 m (150 ft);

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

(e) An automatic altitude-control system should be operative and engaged during level cruise, except when circumstances such as the need to re-trim the aircraft or turbulence require disengagement. In any event, adherence to cruise altitude should be done by reference to one of the two primary altimeters. Following loss of the automatic height keeping function, any consequential restrictions will need to be observed.

(f) Ensure that the altitude-alerting system is operative;

(g) At intervals of approximately one hour, cross-checks between the primary altimeters should be made. A minimum of two will need to agree within ±60 m (±200 ft). Failure to meet this condition will require that the altimetry system be reported as defective and notified to ATC;

(i) The usual scan of flight deck instruments should suffice for altimeter cross-checking on most flights.

(ii) Before entering RVSM airspace, the initial altimeter cross check of primary and standby altimeters should be recorded

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

(h) In normal operations, the altimetry system being used to control the aircraft should be selected for the input to the altitude reporting transponder transmitting information to ATC.

(i) If the pilot is advised in real time that the aircraft has been identified by a height-monitoring system as exhibiting a TVE greater than ±90 m (±300 ft) and/or an ASE greater than ±75 m (±245 ft) then the pilot should follow established regional procedures to protect the safe operation of the aircraft. This assumes that the monitoring system will identify the TVE or ASE within the set limits for accuracy.

(j) If the pilot is notified by ATC of an assigned altitude deviation which exceeds ±90 m (±300 ft) then the pilot should take action to return to cleared flight level as quickly as possible.

5.2 Contingency procedures after entering RVSM airspace are:

5.2.1 The pilot should notify ATC of contingencies (equipment failures, weather) which affect the ability to maintain the cleared flight level, and co-ordinate a plan of action appropriate to the airspace concerned. Appendices 6 and 7 are relevant to EUR and NAT airspace.

Note: Other appendices may be added as necessary to address additional areas of operation.

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

(a) failure of all automatic altitude-control systems aboard the aircraft;

(b) loss of redundancy of altimetry systems;

(c) loss of thrust on an engine necessitating descent; or

(d) any other equipment failure affecting the ability to maintain cleared flight level;

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

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

6. POST FLIGHT

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

6.2 The following information should be recorded when appropriate:

(a) Primary and standby altimeter readings.

(b) Altitude selector setting.

(c) Subscale setting on altimeter.

(d) Autopilot used to control the aeroplane 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.

7. SPECIAL EMPHASIS ITEMS: FLIGHT CREW TRAINING

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

(a) knowledge and understanding of standard ATC phraseology used in each area of operations;

(b) importance of crew members cross checking to ensure that ATC clearances are promptly and correctly complied with;

(c) use and limitations in terms of accuracy of standby altimeters in contingencies. Where applicable, the pilot should review the application of static source error correction/ position error correction through the use of correction cards;
Note: Such correction data will need to be readily available on the flight deck.

(d) problems of visual perception of other aircraft at 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.

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

1. 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. 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. 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 ±25m (±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 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.'

4. ICAO Doc. 9574 recognises 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 recognise 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 recognised that it would be necessary to develop specifications and procedures covering the means for ensuring that in-service degradation is controlled at an acceptable level.

5. 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. These standards provide the basis for the separate performance aspects of airframe, altimetry, altimetry equipment and automatic altitude control system. It is important to recognise 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 25 m (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.

APPENDIX 6 - SPECIFIC PROCEDURES FOR EUROPEAN RVSM AIRSPACE

1 INTRODUCTION

1.1 This Appendix is included for information. It states the procedures that were approved by the EUROCONTROL Airspace and Navigation Team in February 1998.

1.2 The area of applicability will be defined in an amendment to ICAO document 7030 which is expected to be approved in 1998. This appendix will be updated as required in a later issue of this Temporary Guidance Leaflet to take account of the amended ICAO document 7030.

2 DEFINITIONS

For the purposes of these procedures, the following terms will have the following meanings:

<u>Flight Level Allocation Scheme (FLAS):</u>

The scheme whereby specific flight levels may be assigned to specific route segments within the route network

<u>RVSM (Operational) Approval:</u>

The approval that is issued for each individual aircraft by the appropriate State authority once an operator has achieved the following:

I. RVSM Airworthiness approval; and
II. State Approval of operations manual (where applicable) and on-going maintenance procedures.

<u>Strategic Flight Level:</u>

A flight level which is flight-plannable in accordance with the Table of Cruising Levels of ICAO Annex 2, Appendix 3 (see Attachment A) and the Flight Level Allocation Scheme (FLAS), as specified in the relevant Aeronautical Information Publications.

<u>Tactical Flight Level:</u>

A flight level which is not flight-plannable and which is reserved for tactical use by ATC.

3 AREA OF APPLICABILITY

3.1 Except for State aircraft operating as Operational Air Traffic (OAT), and as per the provisions of ICAO Annex 2, Appendix 3, only flight operations conducted under IFR shall be permitted in the RVSM airspace.

3.2 The RVSM procedures shall apply to operations between FL 290 and FL 410 inclusive in the Flight Information Regions/Upper Information Regions (FIRs/UIRs)as defined in ICAO doc 7030.

3.3 Provisions for the transition of aircraft, including the accommodation of civil aircraft non-RVSM approved within RVSM airspace for the purpose of clearing aircraft to flight levels appropriate to the adjacent operating environment, shall be applicable in the FIRs/UIRs as defined in ICAO doc 7030.

4 PROCEDURES

The ATC procedures related to RVSM include the following:

- General Procedures
- Procedures for non-RVSM approved State Aircraft operating as General Air Traffic (GAT) within the RVSM airspace
- Procedures for State Aircraft Operating as OAT, Crossing ATS Routes, within the RVSM Airspace
- Procedures relative to Airspace Restrictions and Reservations
- Flight planning procedures
- Inter-centre co-ordination procedures
- Contingency procedures
- Transition procedures
- Phraseology

5 GENERAL PROCEDURES.

5.1 ATC shall only clear RVSM approved aircraft into the RVSM airspace, except for State aircraft and except as provided for in paragraph 11.

Note: See Paragraph 12 for applicable controller-pilot RTF.

5.2 ATC shall provide a minimum of 300m (1,000 ft) vertical separation between RVSM approved aircraft operating within the RVSM airspace.

5.3 ATC shall provide a minimum of 600m (2,000 ft) vertical separation between any non-RVSM approved State aircraft and any other aircraft operating within the RVSM airspace.

5.4 In airspace where transition tasks are carried out (sub-paragraph 3.3 above refers), ATC shall provide a minimum of 600m (2,000 ft) vertical separation between any non-RVSM approved aircraft and any other aircraft.

5.5 ATC shall withhold clearance into the RVSM airspace for all formation flights involving civil aircraft.

5.6 ATC shall provide a minimum of 600m (2,000 ft) vertical separation between all formation flights involving State aircraft and any other aircraft operating within the RVSM airspace.

5.7 ATC shall assign flight levels to non-RVSM approved aircraft, other than State aircraft, in accordance with the table below:

	Landing aerodrome within lateral limits of RVSM airspace	Landing aerodrome outside lateral limits of RVSM airspace
Departing aerodrome within lateral limits of RVSM airspace	Assign level **below** RVSM airspace	Assign level **below** RVSM airspace
Departing aerodrome outside lateral limits of RVSM airspace	Assign level **below** RVSM airspace	Assign level **below or above** RVSM airspace

6 PROCEDURES FOR STATE AIRCRAFT OPERATING AS OPERATIONAL AIR TRAFFIC (OAT), CROSSING ATS ROUTES, WITHIN THE RVSM AIRSPACE.

6.1 The majority of State aircraft operating as OAT will be non altimetry MASPS compliant. Therefore, as a basic principle, and unless otherwise notified, State aircraft operating as OAT shall be considered as being non-RVSM approved.

6.2 The minimum vertical separation required between (a) State aircraft operating as OAT, crossing ATS routes, and (an) aircraft operating as GAT, where both are operating within the RVSM airspace, shall be 600m (2,000 ft).

6.3 However, in an airspace environment where both the civil and military ATC units are fully aware as to the RVSM approval status of all traffic involved, a reduced vertical separation of 300m (1,000 ft) can be applied between a RVSM approved State aircraft operating as OAT, and RVSM approved GAT.

7 PROCEDURES RELATIVE TO AIRSPACE RESTRICTIONS AND /OR RESERVATIONS

Note: The procedures specified in this paragraph 7 are subject to further review by the EUROCONTROL Airspace and Navigation Team after the implementation of a common methodology of delineation, publication and use of restricted and/or reserved airspace.

7.1 Unless an appropriate horizontal spacing exists:

7.1.1 ATC shall provide a minimum 600m (2,000 ft) vertical spacing below the published lower limit of an airspace restriction and/or reservation with a published lower limit of FL 300 or above and aircraft operating within the vertical limits of the RVSM airspace so as to ensure that vertical separation minima are not infringed.

7.1.2 ATC shall provide a minimum 600m (2,000 ft) vertical spacing above the published upper limit of an airspace restriction and/or reservation and aircraft operating within the vertical limits of the RVSM airspace so as to ensure that vertical separation minima are not infringed.

7.2 Consequently:

7.2.1 The first flight level usable by ATC below an airspace restriction and/or reservation shall be 600m (2,000 ft) below the published lower limit of such airspace, where the published lower limit is FL 300 or above.

7.2.2 The first flight level usable by ATC above an airspace restriction and/or reservation shall be 600m (2,000 ft) above the published upper limit of such airspace, where the published upper limit is FL 290 or above.

8 FLIGHT PLANNING

8.1 The flight plan submitted for a flight intending to operate across the lateral limits of the RVSM airspace shall include:

- the specific requested flight level for that portion of the route commencing immediately after the entry point at the lateral limits of the RVSM airspace, consistent with the FLAS, if published;
- the specific requested flight level for that portion of the route commencing immediately after the exit point at the lateral limits of the RVSM airspace, consistent with the FLAS, if published.

8.2 All operators of RVSM approved aircraft, shall insert the letter "**W"** in Item 10 of the ICAO Flight Plan, regardless of the requested flight level.
Note: to be included in the flight planning section of Doc. 7030.

8.3 All operators of non-RVSM approved State aircraft with a requested flight level of FL 290 or above, shall insert the phrase "**STS/NONRVSM"** in Item 18 of the ICAO Flight Plan.

8.4 Operators of customs or police aircraft shall insert the letter "**M**" in Item 8 of the ICAO Flight Plan if non-RVSM approved and intending to operate within the RVSM airspace.

8.5 All operators filing repetitive flight plans (RPLs) shall include in Item Q equipment information in regards to their RVSM approval status in the format **"EQPT/W",** for flights RVSM approved and **"EQPT/ ",** for flights non RVSM approved with operational service ceilings corresponding to FL 250 regardless of the requested flight level.

Note: the ability to address Item Q with equipment information is to be confirmed as policy.

8.6 Operators of State aircraft, not RVSM approved, filing repetitive flight plans including a requested Flight Level of FL 290 or above, shall include **"STS/NONRVSM"** in Item Q.

Note: The ability to address Item Q with equipment information is to be confirmed as policy.

8.7 Regardless of the RVSM approval status of the individual aircraft concerned, the letter "**W**" shall never be inserted in Item 10 of flight plans related to formation flights involving State aircraft.

8.8 Operators of formation flights involving State aircraft intending to operate as General Air Traffic (GAT) in RVSM airspace shall include **"STS/NONRVSM"** in Item 18 of the ICAO Flight Plan.

9 INTER-CENTRE CO-ORDINATION

9.1 The On-line Data Exchange System should support the co-ordination of requests for special handling (e.g.: STS) as filed in Item 18 of the ICAO Flight Plan.

9.2 Computer Assisted Co-ordination of Estimate Messages.

In the case of automated messages not containing the information provided in Item 18 of the flight plan relating to RVSM operations, the sending air traffic control unit shall inform the receiving air traffic control unit of that information by verbally supplementing the activation message.

Note: See paragraph 12 below for details of the precise RTF to be used.

9.3 Verbal Co-ordination of Estimate Messages

When a verbal co-ordination process is being used, the sending air traffic control unit shall include the information filed in Item 18 of the ICAO flight plan, relevant to RVSM operations, at the end of the verbal estimate message.

Note: See paragraph 12 for details of the precise RTF to be used.

9.4 For the case of a single aircraft experiencing an in flight contingency, the associated co-ordination messages shall be supplemented verbally by a description of the cause of the contingency.

Note: See paragraph 12 for details of the precise RTF to be used.

10 CONTINGENCY PROCEDURES

Note: See paragraph 12 for details of the precise co-ordination RTF to be used.

10.1 Procedures applicable to individual aircraft.

Equipment related:

10.1.1 Where an aircraft's Mode C displayed level indicates a deviation from the cleared flight level of 90m (300 ft). or more, the controller shall inform the pilot as soon as practicable and the pilot shall return to his cleared flight level immediately.

10.1.2 When informed by the pilot that the aircraft's equipment has degraded to below altimetry MASPS compliance levels while operating within the RVSM airspace, the controller shall provide for either a minimum vertical separation of 600m (2,000 ft) or an appropriate horizontal separation. Controllers shall normally clear the aircraft below FL 290 before the next inter-centre transfer of control point, unless otherwise co-ordinated.

Weather related:

10.1.3 For the case of an individual aircraft reporting severe turbulence, the controller shall provide for either an appropriate horizontal separation, or an increased vertical separation.

10.1.4 If informed of the existence of severe turbulence, the controller shall solicit other relevant turbulence reports to determine, in co-ordination with the Supervisor, whether RVSM operations should be suspended entirely or within a specific level band and/or area.

10.2 Procedures for multiple aircraft.

Weather related, non-predicted:

10.2.1 For the case of immediate requirements where a controller has received no advance warning of impending meteorological conditions that could create severe turbulence, the controller shall provide for an increased minimum vertical separation or an appropriate horizontal separation, and the following, although not exhaustive, should be considered:

- Since each real time situation will demand very specific, distinct actions, the controller should use his/her best judgement to ensure the safety of the aircraft under his/her responsibility.
- The controller should pass traffic information to the extent possible.
- The controller will co-ordinate with the Supervisor for the purpose of determining whether RVSM operations will be suspended entirely or within a specific level band and/or area.
- If a reversion to Conventional Vertical Separation Minima is deemed necessary, co-ordination with adjacent ACCs shall be accomplished to ensure an orderly progression to the transfer of traffic under Conventional Vertical Separation Minima conditions.
- Supervisors may co-ordinate, to the extent deemed necessary, a request for the deactivation of any airspace restrictions and/or reservations required to provide additional radar vectoring airspace necessary to facilitate the transition to Conventional Vertical Separation Minima.
- The Supervisor should co-ordinate with the parent flow management position to adjust the applicable sector capacities.

Weather related, predicted:

10.2.2 For the case of meteorological conditions causing severe turbulence, predicted by Meteorological Services, the procedures required will of consequence be of a strategic nature. A meteorological forecast, predicting severe turbulence, received by an ACC, will demand of the Supervisor a decision as to whether RVSM operations are to be interrupted, for what period of time, and for what specific level(s) and/or area. Should an increased vertical separation be necessary, the Supervisor will co-ordinate with the adjacent ACCs concerned as to the flight levels appropriate for the transfer of traffic, unless a contingency FLAS has been determined in the Letter of Agreement. The Supervisor should co-ordinate with the parent flow management position to establish the applicable sector capacities. The issuance of a NOTAM should be considered as circumstances require.

11 TRANSITION PROCEDURES

11.1 For aircraft to be transferred from RVSM airspace to non-RVSM airspace, the last area control centre providing air traffic control service to such aircraft shall establish a minimum of 600m (2,000 ft) vertical separation before the aircraft passes the transfer of control point to the adjacent area control centre established at a flight level in accordance with the ICAO Table of Cruising Levels as published in ICAO Annex 2, Appendix 3, table b), and/or in accordance with the FLAS, if applicable, and/or as specified in the inter-centre Letter of Agreement.

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11.2 For aircraft transferred from non-RVSM airspace to RVSM airspace, the first area control centre providing air traffic control service to such aircraft shall ensure that RVSM approved aircraft and non-RVSM approved State aircraft are cleared so as to be established at a flight level in accordance with the ICAO Table of Cruising Levels as published in ICAO Annex 2, Appendix 3, table a), and/or in accordance with the FLAS, if applicable and/or as specified in the inter-centre Letter of Agreement, before the aircraft passes the transfer of control point to the adjacent ACC.

11.3 For aircraft landing at an aerodrome within the lateral limits of the RVSM airspace, the first area control centre providing air traffic control to aircraft transferred to RVSM airspace from non-RVSM airspace shall ensure that non-RVSM approved aircraft, except State aircraft, are cleared so as to be established at a flight level below FL 290 in accordance with the FLAS, if applicable and/or as specified in the inter-centre Letter of Agreement, before the aircraft passes the transfer of control point to the adjacent ACC.

11.4 For aircraft landing at an aerodrome outside and transiting the lateral limits of the RVSM airspace, the first area control centre providing air traffic control to aircraft transferred to RVSM airspace from non-RVSM airspace shall ensure that non-RVSM approved aircraft, except State aircraft, are cleared so as to be established at a flight level below FL 290 or above FL 410 before the aircraft passes the transfer of control point to the adjacent area control centre in accordance with the FLAS, if applicable and/or as specified in the inter-centre Letter of Agreement.

12 PHRASEOLOGY

12.1 Controller-pilot RTF: (* *indicates a pilot transmission)*

Paragraph	Message	Phraseology
12.1.1	To ascertain the RVSM approval status of a flight:	*(callsign)* **CONFIRM RVSM APPROVED**
12.1.2	Pilot indication of non-RVSM approval status: To be stated: I. in the initial call on any frequency within the RVSM airspace (*controllers shall provide a readback with this same phrase)*, and II. in all requests for flight level changes pertaining to flight levels within the RVSM airspace III. in all readbacks to flight level clearances pertaining to flight levels within the RVSM airspace As well, pilots of aircraft, other than State aircraft, shall respond to level clearances involving the vertical transit through either FL 290 or FL 410 with this phrase.	**NEGATIVE RVSM ***
12.1.3	State aircraft, not RVSM approved, shall indicate their status as being that of a State aircraft, in conjunction with a negative response to the RTF indicated in sub-paragraph. 12.1.1, with the phrase:	**NEGATIVE RVSM STATE AIRCRAFT***
12.1.4	Denial of clearance into the RVSM airspace:	*(callsign)* **UNABLE CLEARANCE INTO RVSM AIRSPACAsia PacificE, MAINTAIN [***or* **DESCEND TO,** *or* **CLIMB TO] FLIGHT LEVEL** *(number)*

Paragraph	Message	Phraseology
12.1.5	For the case of an individual aircraft reporting severe turbulence or other severe weather related phenomenon, the pilot phraseology shall be:	**UNABLE RVSM DUE TURBULENCE***
12.1.6	The phraseology required of a pilot to communicate those circumstances which would cause an aircraft's equipment to degrade to below altimetry MASPS compliance levels shall be: The phrase is to be used to convey both the initial indication of the non-altimetry MASPS compliance and, henceforth, on initial contact on all frequencies within the RVSM airspace until such time as the problem ceases to exist. The phrase is to be used to convey both the initial indication of the non-altimetry MASPS compliance and, henceforth, on initial contact on all frequencies within the lateral limits of the RVSM airspace.	**UNABLE RVSM DUE EQUIPMENT***
12.1.7	The pilot shall communicate his/her ability to resume operation within the RVSM airspace after an equipment related contingency, or his/her ability to resume RVSM operations after a weather related contingency with the phrase:	**READY TO RESUME RVSM***
12.1.8	Controllers wishing to solicit this information shall use the phrase:	**REPORT ABLE TO RESUME RVSM**

12.2 Co-ordination between ATS units:

Paragraph	Message	Phraseology
12.2.1	To verbally supplement an automated estimate message exchange which does not automatically transfer Item 18 information:	**NEGATIVE RVSM**
12.2.2	To verbally supplement estimate messages of flights non-RVSM approved:	**NEGATIVE RVSM**
12.2.3	To communicate the cause of a single aircraft contingency:	**UNABLE RVSM DUE TURBULENCE [***or* **EQUIPMENT,** *as applicable***]**

APPENDIX 7 - SPECIFIC PROCEDURES FOR THE NORTH ATLANTIC AIRSPACE

1. INTRODUCTION

1.1 North Atlantic Minimum Navigation Performance Specification (NAT MNPS) airspace is the area where RVSM has been first implemented. The guidance that follows should be applied when RVSM is in use in NAT MNPS airspace.

1.2 This Appendix contains information on 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 that relate to lateral as well as vertical navigation are discussed.

2. GENERAL INFORMATION: AIRSPACE DIMENSIONS

2.1 Entry into NAT RVSM airspace requires the holding approvals for both lateral navigation and height keeping performance.

2.2 NAT MNPS airspace has a ceiling of FL 420 and a base of FL 285 with 300m (1,000 ft) vertical separation applied to aircraft operating at and between FL 290 and FL 410.

3. INTENDED USE OF THIS APPENDIX MATERIAL

3.1 Paragraph 4, Basic Concepts for Contingencies

This paragraph provides an overview of contingency procedures. It is intended to direct the pilot's thinking to the concepts involved and aid in understanding the specific guidance detailed in paragraphs 5 and 6. This material should be included in training programmes and appropriate operations manuals.

3.2 Paragraph 5, Guidance to the Pilot in the Event of Equipment Failures or Encounters with Turbulence after Entering NAT MNPS Airspace

This paragraph 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 programmes and appropriate operations manuals.

3.3 Paragraph 6 and Supplement, Doc. 7030 North Atlantic Contingency Procedures

In this paragraph and the Supplement to this Appendix, North Atlantic Regional Supplementary Procedures (Doc 7030) paragraph 6, Special Procedures for In-flight Contingencies (applicable when RVSM is implemented) are reprinted for ease of reference. Doc. 7030 paragraph 6 gives guidance on actions to be taken by the pilot. Pilot actions should be considered required pilot knowledge. The material may be condensed for ease of presentation and should be included in training/qualification programmes and appropriate operations manuals.

3.4 Paragraphs 7 and 8

Paragraph 7 discusses RVSM transition areas. Paragraph 8 is a general discussion of pilot action in relation to the proposed RVSM monitoring system. These paragraphs should be covered in training programmes and operations manuals.

3.5 Paragraph 9 Expanded RVSM Equipment Failure and Turbulence Scenarios

This paragraph reviews the situations discussed in paragraph 5 in greater detail. The material may be used in training programmes as an operator considers necessary.

4. BASIC CONCEPTS FOR CONTINGENCIES

4.1 General

The NAT Regional Supplementary Procedures document (Doc. 7030) were revised to provide for RVSM implementation in NAT MNPS airspace. The North Atlantic Systems Planning Group developed draft paragraph 6 revisions that were endorsed by the Limited NAT Regional Air Navigation Meeting in November 1992. They have been made effective at the start of operational trials which commenced on 27 March 1997. The NAT MNPS Operations Manual has been revised with this material.

4.2 The basic concepts for contingencies, described in this paragraph, have been developed from the specific guidance contained in Doc. 7030 paragraph 6 reprinted in the Supplement to this Appendix. Contingency procedures are complicated when specific situations are detailed. However, if the details are examined in the context of certain basic concepts, then they are more easily understood. Reviewing these concepts should serve to aid pilots understanding of the specific contingency procedures detailed in Doc. 7030.

4.3 The basic concepts for contingencies are:

4.3.1 *Pilot in Command Responsibility* Guidance for contingency procedures should not be interpreted in any way that prejudices the final authority and responsibility of the pilot-in-command for the safe operation of the aircraft.

4.3.2 If the pilot is unsure of the vertical or lateral position of the aircraft or the aircraft deviates intentionally from its assigned flight level or track, without prior ATC clearance, then the pilot will need to take action to mitigate the potential for collision with aircraft on adjacent routes or flight levels.

In this situation, the pilot should alert adjacent aircraft by making maximum use of aircraft lighting and broadcasting position, flight level and intentions on 121.5 MHz, or 131.8 MHz as a back-up frequency.

4.3.3 Unless the nature of the contingency dictates otherwise, the pilot should advise ATC as soon as possible of the problem and request an ATC clearance before deviating from the assigned route or flight level.

4.3.4 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 a flight level and/or on a track where other aircraft are least likely to be encountered.

This can be accomplished by off-setting the aircraft from routes or flight levels normally flown in the airspace. Doc. 7030 paragraph 6 provides recommendations on the preference for the pilot's following actions:

(a) Offsetting half the lateral distance between routes or tracks, or

(b) Offsetting half the vertical distance between flight level normally flown.

(c) Descending below FL 285 or climbing above FL 410. Flight flown at these levels limits the possibility of conflict with other aircraft.

4.3.5 When executing a contingency manoeuvre the pilot should:

(a) Watch for conflicting traffic.

(b) Continue to alert other aircraft using 121.5 MHz or 131.8 MHz and aircraft lights.

(c) Continue to fly tracks or flight levels which are likely to be unoccupied.

(d) Obtain an ATC clearance as soon as possible.

5. 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 In addition to emergencies that require immediate descent, such as loss of thrust or pressurisation, ATC should be made aware of conditions that may make it impossible for an aircraft to maintain its cleared flight level appropriate to RVSM. Controllers will react to such conditions but these actions cannot be specified, as they will depend upon the situation at the time.

5.2 Objective of the Guidance Material

The following material is provided with the purpose of giving the pilot guidance on actions to take under certain conditions of equipment failure and encounters with turbulence. It also describes the expected ATC controller actions in these situations. It is recognised that the pilot and controller will use judgement to determine the action most appropriate to any given situation. The guidance material recognises that for certain equipment failures, the safest course of action may be for the aircraft to continue in MNPS airspace while the pilot and controller take precautionary action to protect separation. For extreme cases of equipment failure, however, the guidance recognises 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 contingency manoeuvre to leave the assigned route or track.

Note: Paragraph 9 gives an expanded description of the scenarios listed below:

5.3 Contingency Scenario

The pilot is unsure of the vertical position of the aircraft due to loss or degradation of all primary altimetry systems or is unsure of the capability to maintain cleared flight level due to turbulence or loss of all automatic altitude control systems.

5.3.1 *Pilot Actions* The pilot should maintain cleared flight level while evaluating the situation and:

(a) Watch for conflicting traffic

(b) If considered necessary, alert nearby aircraft by:

(i) Making maximum use of exterior lights;

(ii) Broadcasting position, flight level, and immediate intentions on 121.5 MHz or 131.8 MHz as a back up.

(c) Notify ATC of the situation and the intended course of action. Possible courses of action include:

(i) Continuing in MNPS airspace provided that the aircraft can maintain the cleared flight level.

(ii) Requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft cannot maintain the cleared flight level and ATC cannot establish adequate separation from other aircraft.

(iii) Executing the Doc. 7030 contingency manoeuvre to leave the assigned track if prior ATC clearance cannot be obtained and the aircraft cannot maintain cleared flight level.

5.3.2 *Expected ATC actions* The following information is provided for information purposes. ATC can be expected to:

(a) Obtain the pilot's intentions;

(b) If the pilot intends to continue in MNPS airspace, consider establishing increased vertical, longitudinal, or lateral separation;

(c) Pass traffic information;

(d) If the pilot requests clearance to exit MNPS airspace, accommodate expeditiously, if possible;

(e) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit MNPS airspace, ATC can be expected to notify other aircraft nearby and continue to monitor the situation.

(f) Advise adjoining ATC facilities/sectors of the situation.

<u>5.4 Contingency Scenario</u>

Failure or loss of accuracy of one primary altimetry system; for example, 60m (200 ft) or more difference between primary altimeters.

5.4.1 *Pilots Actions* 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 system accuracy, follow the actions stated in the preceding scenario.

6. DOC 7030 NORTH ATLANTIC CONTINGENCY PROCEDURE

The revised contingency procedures for RVSM are reprinted in a supplement to this Appendix 7 for ease of reference. However, Doc. 7030 is the source document for NAT contingency procedures. Doc. 7030 and the North Atlantic MNPS Airspace Operations Manual should be consulted before preparing training material.

7. TRANSPONDER FAILURE AND RVSM TRANSITION AREAS

The specific actions taken by ATC in the event an aircraft's transponder failure in an RVSM transition area will be determined by the provider States.

Note: Transition areas have been implemented where different separation standards exist between adjacent airspace.

8. HEIGHT MONITORING

A height-monitoring system is an element of the RVSM implementation programme for the NAT with regional procedures for its use.

9. EXPANDED GUIDANCE FOR RVSM EQUIPMENT FAILURE AND TURBULENCE SCENARIOS

The scenarios given below expand upon the basic concepts given in paragraph 5. They may be used as the basis for training programmes.

<u>9.1 Scenario: All automatic altitude control systems fail (e.g. automatic altitude hold)</u>

9.1.1 *Initial actions* The pilot should:

(a) Maintain cleared flight level

(b) Evaluate the aircraft's capability to maintain flight level through manual control.

9.1.2 *Subsequent actions* The pilot should:

(a) Watch for conflicting traffic;

(b) If considered necessary, alert nearby aircraft by;

(i) Making maximum use of exterior lights:

(ii) Broadcasting position, flight level and immediate intentions on 121.5 MHz.(131.8 MHz may be used as a back-up);

(c) Notify ATC of the failure and the intended course of action. Possible courses of action include:

(i) Continuing in MNPS airspace provided that the aircraft can maintain the cleared flight level.

(ii) Requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft cannot maintain flight level and ATC cannot establish increased vertical, longitudinal, or lateral separation.

(d) Executing the Doc. 7030 contingency manoeuvre to leave the assigned route or track if prior ATC clearance cannot be obtained and the aircraft cannot maintain level.

9.1.3 *Expected ATC actions* ATC can be expected to:

(a) Obtain the pilot's intentions.

(b) If the pilot intends to continue in MNPS airspace, consider establishing increased vertical, longitudinal, or lateral separation.

(c) Pass traffic information.

(d) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.

(e) If increased vertical, longitudinal, or lateral separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, ATC can be expected to notify other aircraft nearby and continue to monitor the situation. In this situation, the pilot may be executing his authority to protect the safety of the aircraft by flying the established contingency procedures to leave the assigned route or track.

(f) Advise adjoining ATC facilities/sectors of the situation.

9.2 Scenario: Loss of redundancy in primary altimetry systems

9.2.1 *Course of action* The pilot should take the following action:

If the remaining altimetry system is functioning normally, couple that system, where possible, to the automatic altitude control system, notify ATC of the loss of redundancy and maintain vigilance of altitude keeping.

9.2.2 *Expected ATC actions* ATC can be expected to acknowledge the situation and continue to monitor progress.

9.3 Scenario: All primary altimetry systems fail or are considered unreliable

9.3.1 *Initial actions* The pilot should:

(a) Maintain altitude by reference to the standby altimeter (if the aircraft is so equipped);

(b) Alert nearby aircraft by:

(i) Making maximum use of exterior lights; and

(ii) Broadcasting position, flight level and intentions on 121.5 MHz (131.8 MHz can be used as a back-up).

(c) Notify ATC of the inability to meet MNPS performance requirements, consider declaring an emergency, and request clearance to exit MNPS airspace.

9.3.2 *Subsequent actions* The pilot should:

(a) If unable to obtain ATC clearance, in a timely manner, execute Doc. 7030 contingency procedures to leave the assigned route or track and descend below RVSM airspace (if operationally feasible).

(b) If it is not operationally feasible to execute Doc. 7030 contingency procedures, continue to alert nearby aircraft and co-ordinate with ATC.

9.3.3 *Expected ATC actions* ATC can be expected to:

(a) When notified by the pilot that the aircraft cannot meet MNPS performance requirements, ATC can be expected to accommodate the request for clearance to exit the airspace in an expeditious manner.

(b) If unable to accommodate the request for clearance to exit the airspace, ATC should request the pilot's intentions, advise the pilot of traffic in the proximity, advise other aircraft and continue to monitor the situation.

9.4 Scenario: Primary altimeters diverge by more than ±60 m (±200 ft)

9.4.1 *Course of action* The pilot should:

(a) Attempt to determine the defective system through established trouble shooting procedures and/or comparing the primary altimeter displays to the standby altimeter (as corrected by correction cards, if required)

(b) If the defective system can be determined, couple the functioning altimetry system to the altitude keeping device.

(c) If the altimeter displays differ by more than ±60 m (±200 ft) and it cannot be determined which system is defective, follow the guidance in sub-paragraph 9.1(c) for failure or unreliable altimeter indications of all primary altimeters.

9.5 Scenario: Aircraft encounters turbulence greater than moderate, which the pilot believes will affect the aircraft's capability to maintain flight level

9.5.1 *Course of action* The pilot should:

(a) Watch for conflicting traffic and make maximum use of exterior lights.

(b) Broadcast call sign, position, flight level, nature and severity of turbulence, and intentions on 121.5 MHz (131.8 MHz may be used as a back-up).

(c) Notify ATC as soon as possible and request flight level change if necessary.

(d) If the aircraft cannot maintain level, execute Doc. 7030 contingency procedures to leave the assigned route or track.

9.5.2 *Expected ATC actions* ATC can be expected to:

(a) If possible, establish increased vertical, longitudinal, or lateral separation.

(b) Accommodate the request for change in flight level, if possible.

(c) If neither of the above actions are possible, notify other aircraft in the vicinity and monitor the situation.

(d) Consider suspending RVSM operations in the affected area.

SUPPLEMENT TO APPENDIX 7 - SPECIAL PROCEDURES FOR IN-FLIGHT CONTINGENCIES

Extract from ICAO DOC 7030 Regional Supplementary Procedures, Part 1 RULES OF THE AIR, AIR TRAFFIC SERVICES AND SEARCH AND RESCUE (revised 5 February 1997)

6 SPECIAL PROCEDURES FOR IN-FLIGHT CONTINGENCIES
(P-RAC, Part II-16)

6.1 The following procedures are intended for guidance only. Although all possible contingencies cannot be covered, they provide for the more frequent cases of:

1) inability to maintain assigned level due to weather, aircraft performance, pressurisation failure and problems associated with high level supersonic flight;

2) loss of, or significant reduction in, the navigation capability when operating in parts of the airspace where high accuracy of navigation is a prerequisite to the safe conduct of flight operations; and

3) en route diversion across the prevailing NAT traffic flow.

With regard to 1) and 3) above, the procedures are applicable primarily when rapid descent and/or turn-back or diversion is required. The pilot's judgement shall determine the sequence of actions taken, and air traffic control shall render all possible assistance having regard to the specific circumstances.

6.2 General Procedures

The following general procedures apply to both subsonic and supersonic aircraft.

6.2.1 If an aircraft is unable to continue flight in accordance with its air traffic control clearance, a revised clearance shall, whenever possible, be obtained prior to initiating any action. This shall also apply to aircraft which are unable to maintain an accuracy of navigation on which the safety of the separation minima applied by air traffic control between it and adjacent aircraft depends. This shall be accomplished using the radiotelephony distress or urgency signal as appropriate. Subsequent air traffic control action with respect to that aircraft shall be based on the intentions of the pilot and the overall air traffic situation.

6.2.2 If prior clearance cannot be obtained, an air traffic control clearance shall be obtained at the earliest possible time and, in the meantime, the pilot shall:

1) broadcast position (including the ATS route designator or the track code, as appropriate) and intentions on frequency 121.5 MHz at suitable intervals until air traffic control clearance is received;

2) make maximum use of aircraft lights to make the aircraft visible;

3) maintain a watch for conflicting traffic; and

4) initiate such action as necessary to ensure safety of the aircraft.

6.3 Special contingency procedures for subsonic aircraft

6.3.1 The following guidance is recommended for aircraft operating within North Atlantic airspace.

6.3.2 Initial action

6.3.2.1 If unable to comply with the provision of 6.2.1 to obtain prior air traffic control clearance, the aircraft should leave its assigned route or track by turning 90 degrees to the right or left whenever this is possible. The direction of the turn should, where possible, be determined by the position of the aircraft relative to any organised route or track system (e.g. whether the aircraft is outside, at the edge of, or within the system). Other factors which may affect the direction of the turn are the direction of an alternate airport, terrain clearance and the levels allocated to adjacent routes or tracks.

6.3.3 Subsequent action

6.3.3.1 An aircraft able to maintain its assigned flight level should:

1) turn to acquire and maintain in either direction a track laterally separated by 30 NM from its assigned route or track; and
2) if above FL 410, climb or descend 300m (1,000 ft); or
3) if below FL 410, climb or descend 150m (500 ft); or
4) if at FL 410, climb 300 m (1,000 ft) or descend 150 m (500 ft).

6.3.3.2 An aircraft not able to maintain its assigned flight level should:

1) initially minimise its descent rate to the extent that it is operationally feasible;
2) turn while descending to acquire and maintain in either direction a track laterally separated by 30 NM from its assigned route or track; and
3) for the subsequent level flight, a level should be selected which differs from those normally used by 300 m (1,000 ft) if above FL 410 or by 150 m (500 ft) if below FL 410.

6.3.4 En route diversion across the prevailing NAT air traffic flow

6.3.4.1 The guidance in sub-paragraph 6.3.4.3 applies to aircraft that:

1) are operating within the OTS or on random routes that are proximate to the OTS; and
2) can climb or descend to an altitude above or below those where the majority of NAT aircraft operate.

Sub-paragraph 6.3.4.4 contains guidance for other situations where diversion across adjacent tracks or routes is necessary.

6.3.4.2 The basic concept of this guidance is that, when operationally feasible, before diverting across tracks or routes with heavy traffic, the aircraft should offset from the assigned track or route by 30 NM and expedite a descent to an altitude below or a climb to an altitude above those where the vast majority of NAT aircraft operate before proceeding toward the alternate aerodrome. Flight below FL 285 or above FL 410 should meet this objective.

6.3.4.3 In the event of a contingency which necessitates an en route diversion to an alternate aerodrome, across the direction of the prevailing NAT traffic flow, and prior ATC clearance cannot be obtained:

6.3.4.3.1 An aircraft able to maintain its assigned flight level should:

1) turn toward the alternate aerodrome to acquire a track which is separated laterally by 30 NM from the assigned route or track; and
2) if above FL 410, climb or descend 300 m (1,000 ft); or
3) if below FL 410, climb or descend 150 m (500 ft); or
4) if at FL 410, climb 300 m (1,000 ft) or descend 150m (500 ft); and
5) fly the offset track while expediting its descent to an altitude below FL 285 or a climb to an altitude above FL 410; and
6) when below FL 285 or above FL 410, proceed towards the alternate aerodrome while maintaining a level which differs from those normally used by 150 m (500 ft) if below FL 410 or 300 m (1,000 ft) if above FL 410; or
7) if unable or unwilling to make a major climb or descent, fly an altitude offset for the diversion until obtaining an ATC clearance. See sub-paragraph 6.3.4.4 below.

6.3.4.3.2 An aircraft not able to maintain its assigned flight level should:

1) initially minimise its descent rate to the extent it is operationally feasible; and
2) start its descent while turning to acquire a track separated laterally by 30 NM from its assigned route or track; and
3) unless the nature of the contingency dictates otherwise, maintain the offset track while expediting its descent to an altitude below FL 285; and
4) unless the nature of the contingency dictates otherwise, when below FL 285, it should proceed towards the alternate aerodrome; and
5) continue descent to a level which can be maintained and which differs from those normally used by 150 m (500 ft) if below FL 410.

6.3.4.3.3 If these contingency procedures are employed by a twin-engine aircraft as a result of a shutdown of a power unit or a primary aeroplane system failure, the pilot should so advise ATC as soon as practicable, reminding ATC of the type of aircraft involved and requesting expeditious handling.

6.3.4.4 Aircraft which are required to divert across the prevailing NAT air traffic flow and are:

1) unable or unwilling to descend to an altitude below those where the majority of NAT aircraft operate due to operational constraints; or
2) unsure of their proximity to other routes or tracks; or
3) assigned to a route which crosses the OTS at a significant angle;

should execute the actions specified in sub-paragraphs 6.3.4.4.1 or 6.3.4.4.2 below.

6.3.4.4.1 An aircraft which is able to maintain its assigned flight level should:

1) if above FL 410, climb or descend 300 m (1,000 ft); or

2) if below FL 410, climb or descend 150 m (500 ft); or

3) if at FL 410, climb 300 m (1,000 ft) or descend 150 m (500 ft)

while turning to proceed toward the alternate aerodrome.

6.3.4.4.2 An aircraft which is unable to maintain its assigned flight level should:

1) expedite a descent to an altitude below those where the majority of NAT aircraft operate while turning toward the alternate aerodrome; and

2) diligently follow the guidance in sub-paragraph 6.2.2 above in regard to radio calls, aircraft lights and watching for conflicting traffic.