

**Civil Aviation
Advisory Publication
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REDUCED VERTICAL SEPARATION MINIMUM (RVSM) APPROVALS

This publication is only advisory but it gives the CASA preferred method for complying with the Civil Aviation Regulations 1988 (CAR 1988).

It is not the only method, but experience has shown that if you follow this method you will comply with CAR 1988.

Always read this advice in conjunction with the appropriate regulations.

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The relevant regulations and orders

- Regulations 181A-181X (CAR 1988)

Who this CAAP applies to

- Australian operators of Australian or foreign registered aircraft, and flight crews wishing to conduct flights into airspace at FL 290 and above where a 1000 ft vertical separation minimum (VSM) is applied - into airspace designated as Reduced Vertical Separation Minimum (RVSM) airspace.

Why the publication was written

- To provide Australian aircraft owners and operators with comprehensive information on a means of gaining airworthiness and operational approvals for RVSM operations.
- To provide flight crew with sufficient knowledge on RVSM operations to enable them to conduct operations safely.

Status of this CAAP

This is the second issue of the CAAP. The previous issue CAAP 181A-1(0), should be removed and destroyed. This issue amends Appendix 2 introducing revised height monitoring requirements.

For further information

Contact the nearest CASA Airline Operations Office.

1. PURPOSE

This document provides an acceptable means, but not the only means, that can be used by Australian operators to gain approval to conduct flights in airspace or on routes at FL 290 and above where a vertical separation minimum (VSM) of 1000 ft is applied in airspace designated as Reduced Vertical Separation Minimum (RVSM) airspace.

The approvals processes described in this CAAP cover *RVSM airworthiness approvals* for Australian aircraft and *RVSM operational approvals* for Australian operators of Australian or foreign aircraft.

2. REGULATIONS

The relevant regulations are: 181A - 181X (CAR 1988).

3. REFERENCES

An applicant should be familiar with the following documents:

- (a) International Civil Aviation Organization (ICAO)
 - ICAO Doc. 9574, *Manual on the Implementation of a 300 m (1,000 ft) Vertical Separation Minimum Between FL 290 - FL 410 Inclusive*.
(Copies may be obtained from Document Sales Unit, ICAO, 999 University Street, Montreal, Quebec, Canada H3C 5H7)
 - The Guidance Material on the Implementation of a 300M (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Pacific Region.

(See FAA web site: <http://www.faa.gov/ats/ato/rvsm_documentation.htm>)
- (b) Federal Aviation Administration (FAA)
 - 91-RVSM (Change 1): *Interim Guidance Material on the Approval of Operators/Aircraft for RVSM Operations*.

(See FAA web site: <http://www.faa.gov/ats/ato/rvsm_documentation.htm>)
- (c) Joint Aviation Authorities (JAA)
 - JAA Temporary Guidance Leaflet - 6 (Revision 1). *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*.
- (d) RTCA
 - Minimum Aviation System Performance Specification (MASPS)

4. BACKGROUND

4.1 FIRST MAJOR REPORT ON RVSM

ICAO has published two major reports which have provided the basis for the development of RVSM implementation documents. The first was of the sixth meeting of the Review of the General Concept of Separation Panel (RGCSP) (Montreal, 28 November-15 December 1988) which was published in two volumes. Volume 1 summarised the major conclusions reached by the panel and by individual states. Volume 2 presented the complete RVSM study reports of Eurocontrol, the US, Japan, Canada, and the then United Soviet Socialist Republic (USSR). The major conclusions of this report are that:

- (a) RVSM is "technically feasible without imposing unreasonably demanding technical requirements on the equipment"; and
- (b) RVSM would provide "significant benefits in terms of economy and en route airspace capacity."

4.2 SECOND MAJOR REPORT ON RVSM

The second major report published by the RGCSP was the Report of RGCSP/7 (Montreal, 30 October - 20 November 1990). This report contains the draft *Manual on Implementation of a 300 M (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. This manual provides guidance for RVSM implementation planning, airworthiness requirements, flight crew procedures, Air Traffic Control (ATC) considerations, and system performance monitoring.

4.3 INITIAL IMPLEMENTATION

A reduced vertical separation minimum of 1000 feet was introduced from FL 330 to FL 370 in parts of the North Atlantic Minimum Navigation Performance Specification (NAT MNPS) airspace in 1997. In 1998, this was extended to cover FL 310 to FL 390 inclusive.

4.4 OTHER IMPLEMENTATION PROGRAMS

Other RVSM implementation programs are:

- (a) the Pacific ocean (including the oceanic part of the Brisbane Flight Information Region (FIR)) on 24 February 2000 (FL290 to FL390 inclusive);
- (b) the remaining parts of the Brisbane and Melbourne FIRs in March 2001;
- (c) the West Pacific and South China Sea in February 2002; and
- (d) Europe in March 2002.

5. DEFINITIONS AND ABBREVIATIONS

The following definitions are intended to clarify certain specialised terms used in this advisory material.

- (a) 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 (see section 9.2.2 for further explanation).
- (b) Altimetry System Error (ASE) The difference between the pressure altitude displayed to the flight crew when referenced to ISA standard ground pressure setting (29.92 in.Hg/1013.25 hPa) and free stream pressure altitude.
- (c) Assigned Altitude Deviation (AAD) The difference between the transponded Mode C altitude and the assigned altitude/flight level.
- (d) Automatic Altitude Control System Any system which is designed to automatically control the aircraft to a referenced pressure altitude.
- (e) 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.
- (f) Basic RVSM Envelope The range of Mach numbers and gross weights within the altitude ranges FL 290 to FL 410 (or maximum available altitude where an aircraft can reasonably be expected to operate most frequently (see section 9.2.4 (b))).
- (g) Full RVSM Envelope The entire range of operational Mach numbers, w/d, and altitude values over which the aircraft can be operated within RVSM airspace (see section 9.2.4(a)).
- (h) Height-Keeping Capability Aircraft height-keeping performance which can be expected under nominal environmental operating conditions with proper aircraft operating practices and maintenance.
- (i) Height-Keeping Performance The observed performance of an aircraft with respect to adherence to a flight level.
- (j) Non-Group Aircraft An aircraft for which the operator applies for approval based on the characteristics of the unique airframe rather than on a group basis (see section 9.2.3 for further explanation).
- (k) Residual Static Source Error The amount by which static source error (SSE) remains undercorrected or overcorrected after the application of SSEC.
- (l) Static Source Error (SSE) The difference between the pressure sensed by the static system at the static port and the undisturbed ambient pressure.
- (m) Static Source Error Correction (SSEC) A correction for static source error.
- (n) Total Vertical Error (TVE) Vertical geometric difference between the actual pressure altitude flown by an aircraft and its assigned pressure altitude (flight level).
- (o) W/δ Aircraft weight, W, divided by the atmospheric pressure ratio, δ.

6. THE APPROVAL PROCESS

6.1 GENERAL

Airspace where RVSM is applied should be considered special qualification airspace. Australian operators and the aircraft they intend to use in the RVSM airspace must be approved by CASA before the operator can conduct flight in RVSM airspace (refer regulations 181A-181X (CAR 1988)). This document provides guidance for the approval of aircraft types and operators for flight in airspace where RVSM is applied.

6.2 APPROVAL OF AIRCRAFT: AIRWORTHINESS APPROVAL

6.2.1 Types of Approvals

Each aircraft that an Australian operator intends to use in RVSM airspace must have an *RVSM airworthiness approval* or an *RVSM foreign airworthiness approval* before an *RVSM operational approval* will be granted by CASA.

6.2.2 RVSM Airworthiness Approval

An *RVSM airworthiness approval*, in the context of this CAAP, is a written approval given by CASA for an Australian aircraft (i.e. an aircraft registered in Australia) indicating that it is suitable to be operated in RVSM airspace.

6.2.3 RVSM Foreign Airworthiness Approval

An *RVSM foreign airworthiness approval* is an approval given for a foreign aircraft by a competent authority of the country in which the aircraft is registered indicating that the aircraft is suitable to be operated in RVSM airspace.

6.2.4 Applying for an Airworthiness Approval

Section 9 provides guidance for the approval of aircraft which have already entered service and for new build aircraft. An Australian operator seeking approval should contact the manufacturer of the specific aircraft type and CASA's Airline Operations Branch, Canberra, to determine/coordinate the process for RVSM approval.

6.3 APPROVAL OF OPERATOR: OPERATIONAL APPROVAL

6.3.1 RVSM Operational Approval

An *RVSM operational approval*, in the context of this CAAP, is a written approval given by CASA to an Australian operator approving the operator to operate the aircraft covered by the approval in RVSM airspace.

6.3.2 Applying for an Operational Approval

Section 10 of this CAAP contains guidance on continued airworthiness (maintenance) programs for RVSM operations. Section 11 contains guidance on the operational procedures and programs which an operator should adopt for RVSM operation. Australian operators should plan to present these programs to CASA at least 60 days prior to proposed operation.

7. RVSM PERFORMANCE

7.1 GENERAL

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

7.2 RVSM FLIGHT ENVELOPES

For the purposes of RVSM approval, the aircraft flight envelope may be considered in two parts: the *Basic RVSM Envelope* and the *Full RVSM Envelope* (the parameters for these envelopes are detailed in section 9.2.4). The *Basic RVSM Envelope* is the part of the flight envelope where aircraft operate the majority of time. The *Full RVSM Envelope* includes parts of the flight envelope where the aircraft operates less frequently and where a larger ASE tolerance is allowed (see sections 7.3.3 and 7.3.4).

7.3 ALTIMETRY SYSTEM ERROR

7.3.1 Factors Affecting ASE

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

- (a) unit to unit variability of avionics;
- (b) effect of environmental operating conditions on avionics;
- (c) airframe to airframe variability of static source error; and
- (d) effect of flight operating condition on static source error.

7.3.2 Assessment

The assessment of ASE_{mean} and ASE_{3SD} , whether based on measured or predicted data, must, therefore, cover section 7.3.1. The effect of section 7.3.1(d) as a variable can be eliminated by evaluating ASE at the most adverse flight condition in an RVSM flight envelope.

7.3.3 Basic RVSM Envelope

The requirements in the *Basic RVSM Envelope* are:

- (a) at the point in the *Basic RVSM Envelope* where mean ASE reaches its largest absolute value, the absolute value should not exceed 80 ft (25 m); and
- (b) at the point in the *Basic RVSM Envelope* where mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 200 ft (60 m).

7.3.4 Full RVSM Envelope

The requirements in the *Full RVSM Envelope* are:

- (a) at the point in the *Full RVSM Envelope* where mean ASE reaches its largest absolute value, the absolute value should not exceed 120 ft (37 m);
- (b) at the point in the *Full RVSM Envelope* where mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 245 ft (75 m); and
- (c) if necessary, for the purpose of achieving RVSM approval for an aircraft group, an operating restriction may be established to restrict aircraft from conducting RVSM operations in areas of the *Full RVSM Envelope* where the absolute value of mean ASE exceeds 120 ft (37 m) and/or the absolute value of mean ASE plus three standard deviations of ASE exceed 245 ft (75 m). When such a restriction is established, it should be identified in the data package and documented in appropriate aircraft operating manuals, however, visual or aural warning/indication systems should not be required to be installed on the aircraft.

7.3.5 Aircraft Types

Aircraft types for which application for type certification or major change in type design is made after 1 January 1997 should meet the criteria established for the *Basic RVSM Envelope* in the *Full RVSM Envelope* (see section 7.3.3).

7.3.6 ICAO Requirements

The requirement of ICAO Doc. 9574 that each individual aircraft in the group should be built to have ASE contained within ± 200 ft (± 60 m) is discussed in section 9.2.5(d)(vi).

The standards of sections 7.3.3, 7.3.4, and 7.3.5 cannot be applied to non-group aircraft approval because there can be no group data with which to develop airframe to airframe variability. Therefore, a single ASE value has been established that controls the simple sum of the altimetry system errors. In order to control the overall population distribution, this limit has been set at a value less than that for group approval.

Accordingly the standard for aircraft submitted for approval as non-group aircraft, as defined in section 9.2.3 is:

- (a) for all conditions in the *Basic RVSM Envelope*
| Residual static source error + worst case avionics | ≤ 160 ft (50 m)
- (b) for all conditions in the *Full RVSM Envelope*
| Residual static source error + worst case avionics | ≤ 200 ft (60 m)

NOTE: Worst case avionics means that combination of tolerance values, specified by the manufacturer 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 and must be capable of controlling altitude within ± 65 ft (± 20 m) about the acquired altitude when operated in straight and level flight under non-turbulent, non-gust conditions.

NOTE: Aircraft types for which application for type certification or major change in type design is made prior to 1 January 1997 which are equipped with automatic altitude control systems with flight management system/performance management system inputs allowing variations up to ± 130 ft (± 40 m) under non-turbulent, non-gust conditions do not require retrofit or design alteration.

8. AIRCRAFT SYSTEMS

8.1 EQUIPMENT FOR RVSM OPERATIONS

The minimum equipment fit is:

- (a) two independent altitude measurement systems. Each system should comprise of the following elements:
 - (i) cross-coupled static source/system, provided with ice protection if located in areas subject to ice accretion;
 - (ii) equipment for measuring static pressure sensed by the static source, converting it to pressure altitude and displaying the pressure altitude to the flight crew;
 - (iii) equipment for providing a digitally coded signal corresponding to the displayed pressure altitude, for automatic altitude reporting purposes;
 - (iv) SSEC, if needed to meet the performance requirements of sections 7.3.3, 7.3.4, or 7.3.6(a) and (b), as appropriate; and
 - (v) the equipment fit should provide reference signals for automatic control and alerting at selected altitude. These signals should preferably be derived from an altitude measurement system meeting the full requirements of this document, but must in all cases enable the requirements of sections 8.2.6 and 8.3 to be met.
- (b) one Secondary Surveillance Radar (SSR) altitude reporting transponder. If only one is fitted, it should have the capability for switching to operate from either altitude measurement system;
- (c) an altitude alert system; and
- (d) an automatic altitude control system.

8.2 ALTIMETRY

8.2.1 System Definition

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; and
- (b) avionics and/or instruments.

8.2.2 Altimetry System Outputs

The following altimetry system outputs are significant for RVSM operations:

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

8.2.3 Altimetry System Accuracy

The total system accuracy should satisfy the requirements of sections 7.3.3, 7.3.4 or 7.3.6 (a) and (b), as appropriate.

8.2.4 Static Source Error Correction (SSEC)

If the design and characteristics of the aircraft and altimetry system are such that the standards of sections 7.3.3, 7.3.4, or 7.3.6 (a) and (b) are not satisfied by the location and geometry of the static sources alone, then suitable SSEC should be applied automatically within the avionics part of the altimetry system. The design aim for static source error correction, whether aerodynamic/geometric or avionics, should be to produce a minimum residual static source error, but in all cases it should lead to satisfaction of the above standards, as appropriate.

8.2.5 Altitude Reporting Capability

The aircraft altimetry system should provide an output to the aircraft transponder in accordance with regulations of the approving authority.

8.2.6 Altitude Control Output

The requirements are:

- (a) the altimetry system shall provide an output which can be used by an automatic altitude control system to control the aircraft at a commanded altitude. The output may be used either directly or combined with other sensor signals. If SSEC is necessary in order to satisfy the requirements of sections 7.3.4, 7.3.4 or 7.3.6(a) and (b) of this CAAP, then an equivalent SSEC must be applied to the altitude control output. The output may be an altitude deviation signal, relative to the selected altitude, or a suitable absolute altitude output; and
- (b) whatever the system architecture and SSEC system the difference between the output to the altitude control system and the altitude displayed must be kept to the minimum.

8.2.7 Altimetry System Integrity

During the RVSM approval process it must be verified analytically that the predicted rate of occurrence of undetected altimetry system failures 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 budget. No other failures or failure combinations need to be considered.

8.3 ALTITUDE ALERT

The altitude deviation warning system must signal an alert when the altitude displayed to the flight crew deviates from selected altitude by more than a nominal value. For aircraft for which application for type certification or major change in type design is made before 1 January 1997, the nominal value shall not be greater than ± 300 ft (± 90 m). For aircraft for which application for type certification or major change in type design is made after 1 January 1997, the nominal value shall not be greater than ± 200 ft (± 60 m). The overall equipment tolerance in implementing these nominal threshold values shall not exceed ± 50 ft (± 15 m).

8.4 AUTOMATIC ALTITUDE CONTROL SYSTEM

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

NOTE: Aircraft types for which application for type certificates was made prior to 1 January 1997, which are equipped with automatic altitude control system with flight management system/performance management system inputs which allow variations up to ± 130 ft (± 40 m) under non-turbulent, non-gust conditions do not require retrofit or design alteration.

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

9. RVSM AIRWORTHINESS APPROVAL

9.1 GENERAL

Obtaining *RVSM airworthiness approval* is a two stage process which may involve more than one authority:

- (a) 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 the *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 (AFM) 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; and
- (b) 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 AFM 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.

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

For the second step, an aircraft operator then applies to the responsible authority of the state in which the aircraft is registered for airworthiness approval of specific aircraft. For all Australian aircraft, this is the Airline Operations Branch in Canberra. 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 AFM amendment or supplement has been incorporated. Approval by CASA indicates that the aircraft is suitable for RVSM operations. CASA will notify the designated monitoring agency accordingly.

9.2 CONTENTS OF THE DATA PACKAGE

9.2.1 Scope

As a minimum, the data package should consist of the following:

- (a) a definition of the aircraft group or non-group aircraft to which the data package applies;
- (b) a definition of the flight envelope(s) applicable to the subject aircraft;
- (c) the data needed to show compliance with the requirements of sections 7 and 8;
- (d) the compliance procedures to be used to ensure that all aircraft submitted for airworthiness approval meet RVSM requirements; and
- (e) the engineering data to be used to ensure continued in-service RVSM approval integrity.

9.2.2 Definition of Aircraft Group

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

- (a) aircraft should have been manufactured to a nominally identical design and be approved by the same Type Certificate (TC), TC amendment, or Supplemental TC, as applicable;
- (b) the static system of each aircraft should be installed in a nominally identical manner and position. The same SSE corrections should be incorporated in all aircraft of the group;
- (c) the avionics units installed on each aircraft to meet the minimum RVSM equipment requirements of section 8.1 should be manufactured to the manufacturer's same specification and have the same part number; and
- (d) the RVSM data package should have been produced or provided by the airframe manufacturer or design organisation.

NOTE 1: For derivative aircraft it may be possible to utilise the database 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 changes between the parent aircraft and the derivative aircraft.

NOTE 2: Aircraft which have avionics units which are of a different manufacturer or part number may be considered part of the group, if it is demonstrated that this standard of avionics equipment provides equivalent system performance.

9.2.3 Definition of Non-Group Aircraft

If an airframe does not meet the conditions of section 9.2.2 to qualify as a member of a group or is presented as an individual airframe for approval, then it must be considered as a non-group aircraft for the purposes of RVSM approval.

9.2.4 Definition of Flight Envelopes

The RVSM flight envelope is defined as the Mach number, W/δ , and altitude ranges over which an aircraft can be operated in cruising flight within the RVSM airspace. As noted in section 7.2, the RVSM operational flight envelope for any aircraft may be divided into two zones as defined below.

(a) Full RVSM Envelope

- (i) The *Full RVSM 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 which should be considered.

TABLE 1

	Lower Boundary is Identified by:	Upper Boundary is Defined by:
Altitude	<ul style="list-style-type: none"> FL 290 	<i>the lower of the following:</i> <ul style="list-style-type: none"> FL 410 Aircraft maximum certified altitude. Altitude limited by: cruise thrust; buffet; other aircraft flight limitations.
Mach or Speed	<i>the lower of the following:</i> <ul style="list-style-type: none"> Maximum endurance (holding) speed. Manoeuvre speed. 	<ul style="list-style-type: none"> M_{MO}/V_{MO} Speed limited by: Cruise thrust, buffet, or other aircraft flight limitations.
Gross Weight	<ul style="list-style-type: none"> The lowest gross weight compatible with operation in RVSM airspace. 	<ul style="list-style-type: none"> The highest gross weight compatible with operation in RVSM airspace.

(b) Basic RVSM Envelope

- (i) The boundaries for the *Basic RVSM Envelope* are the same as those for the Full RVSM Envelope except in regard to the upper Mach boundary.
- (ii) For the *Basic RVSM 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 manufacturer or design organisation. The boundary may be defined as equal to the upper Mach/airspeed boundary defined for the *Full RVSM Envelope* or a specified 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 aircraft flight limitations.

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

9.2.5 Data Requirements

The data package should contain data sufficient to substantiate that the accuracy standards of section 7 are met.

(a) General

- (i) 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 RVSM envelopes. Note that in the case of group approval the worst flight condition may be different for each of the requirements of sections 7.3.3 and 7.3.4, and each should be evaluated.
- (ii) 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 only be performed once appropriate ground checks have been completed. Uncertainties in application of the method must be assessed and taken into account in the data package. The methods are:
 - (A) precision tracking radar in conjunction with pressure calibration of atmosphere at test altitude;
 - (B) trailing cone;
 - (C) pacer aircraft; or
 - (D) any other method acceptable to CASA.

NOTE: When using pacer aircraft it should be understood that the pacer aircraft must have been directly calibrated to a known standard. It is not acceptable to calibrate a pacer aircraft by another pacer aircraft.

- (b) Altimetry System Error Budget It is implicit in the intent of section 7.3, for group approvals and for non-group approvals, that a trade may be made between the various error sources which contribute to ASE. Separate limits are not specified for the various error sources which contribute to the mean and variable components of ASE as long as the overall ASE accuracy requirements are met.

For example, in the case of 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 which includes all significant error sources. This is discussed in more detail in following sections.

NOTE: Further data on this subject are available on the FAA internet web site under RVSM.

- (c) Avionics Avionics equipment should be identified by function and part number. It must be demonstrated that the avionics equipment can meet the requirements established according to the error budget when the equipment is operated in the environmental conditions expected to be met during RVSM operations.

- (d) Groups of Aircraft Where approval is sought for an aircraft group, the data package must be sufficient to show that the requirements of sections 7.3.3 and 7.3.4 are met. Because of the statistical nature of these requirements, the content of the data package may vary considerably from group to group.
- (i) 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 change in the mean and variability based on geometric inspections and bench test or any other method acceptable to the approving authority. In the case of derivative aircraft it may be possible to utilise data from the parent as part of the data base (an example would be the case of a fuselage stretch where the only difference in mean ASE between groups could be reliably accounted for by analytical means).
 - (ii) 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 3SD. 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.
 - (iii) In many cases one or more of the major ASE error sources will be aerodynamic in nature (such as variations in the aircraft 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 which could be used to provide this substantiation is provided in Figure 3-2 of Appendix 3 of the FAA's guidance material: 91-RVSM.
 - (iv) An error budget should be established to ensure that the standards of sections 7.3.3 and 7.3.4 are met. As noted in section 9.2.5(a)(i), the worst flight condition may be different for each of these standards and therefore the component error values may also be different.
 - (v) In showing compliance with the overall requirements, the component error sources should be combined in an appropriate manner. 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 which are independent of each other are combined by RSS.

- (vi) The methodology described above for group approval is statistical in nature. Comments made in Appendix 6, paragraph 5c of 91-RVSM need further explanation. This item states that "...each individual aircraft in the group shall be built to have ASE contained within ± 200 ft". This does not mean that every airframe should be calibrated with a trailing cone or equivalent to demonstrate that ASE is within 200 ft (60 m). Such an interpretation would be unduly onerous considering the risk analysis allows for a small proportion of aircraft to exceed ± 200 ft. However, it is accepted that if any aircraft is identified as having an error of ± 200 ft (± 60 m) then it should receive corrective action.
- (e) Non-Group Aircraft Where an aircraft is submitted for approval as a non-group aircraft, the data should be sufficient to show that the requirements of section 7.3.6(a) and (b) are met. The data package should specify how the ASE budget has been allocated between residual SSE and avionics error. The operator and CASA should agree on what data is needed to satisfy approval requirements. The following data should be established.
 - (i) Precision flight test calibration of the aircraft to establish its ASE or SSE over the RVSM envelope should be required. Flight calibration should be performed at points in the flight envelope(s) as agreed by the certifying authority. One of the methods prescribed in section 9.2.5(a)(ii) should be used.
 - (ii) 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 certifying authority. Since the purpose of the flight test is to determine the residual SSE, specially calibrated altimetry equipment may be used.
 - (iii) Specifications for the installed altimetry avionics equipment indicating the largest allowable errors will be presented.
 - (iv) Using sections 9.2.5(e)(i) to 9.2.5(e)(iii) above demonstrate that the requirements of section 7.3.6(a) and (b) are met. If subsequent to aircraft approval for RVSM operation avionics units which are of a different manufacturer or part number are fitted, it should be demonstrated that the standard of avionics equipment provides equivalent altimetry system performance.

9.2.6 Compliance Procedures

The data package must include a definition of the procedures, inspections/tests and limits which will be used to insure 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 section 9.2.5(b). The budget allowances will be established by the data package and include a methodology that allows for tracking the mean and SD for new build aircraft. Compliance requirements must be defined for each potential source of error. A discussion of error sources can be found in Appendix 2 of the FAA document 91-RVSM (refer FAA web site).

9.2.7 Operating Restrictions

Where an operating restriction has been adopted (see section 7.3.4(c)), the package should contain data and information necessary to document and establish that restriction.

9.2.8 Continued Airworthiness

For the purposes of continued airworthiness:

- (a) the following items should be reviewed and updated as appropriate to include the effects of RVSM implementation:
 - (i) the Structural Repair Manual with special attention to the areas around the static source, angle of attack sensors and doors if their rigging can affect airflow around the previously mentioned sensors; and
 - (ii) the Master Minimum Equipment List (MMEL); and
- (b) the data package should include descriptions of any special procedures which are not covered in section 9.2.8(a) but may be needed to ensure continued compliance with RVSM requirements as follows:
 - (i) for non-group aircraft where airworthiness approval has been based on flight test, the continuing integrity and accuracy of the altimetry system shall be demonstrated by periodic ground and flight tests of the aircraft and its altimetry system at periods to be agreed with the approving authority. However, alleviation of the flight test requirement may be given if it can be adequately demonstrated that the relationship between any subsequent airframe/system degradation and its effects on altimetry system accuracy is understood and adequately compensated/corrected for;
 - (ii) to the extent possible, in-flight defect reporting procedures should be defined to facilitate identification of altimetry system error sources. Such procedures could cover acceptable differences between primary and alternate static sources, and others as appropriate; and
 - (iii) 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.

9.3 RVSM AIRWORTHINESS APPROVAL

All necessary data should be submitted to the appropriate certificating authority for action. The approved data package should be used by the operator to demonstrate compliance with RVSM performance standards.

9.4 POST-APPROVAL MODIFICATION

Any variation/modification from the initial installation that affects RVSM approval should require clearance by the airframe manufacturer or approved design organisation and be cleared with CASA to show that RVSM compliance has not been impaired.

10. CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS)

10.1 GENERAL

The integrity of the design features necessary to ensure that altimetry systems continue to meet RVSM standards should be verified by scheduled tests and/or inspections in conjunction with an approved maintenance program. The operator should review its maintenance procedures and address all aspects of continuing airworthiness which are affected by RVSM requirements.

Each operator should demonstrate that adequate maintenance facilities are available to ensure continued compliance with the RVSM maintenance requirements.

10.2 MAINTENANCE PROGRAM APPROVAL REQUIREMENTS

Each operator requesting an *RVSM operational approval* should submit a maintenance and inspection program which includes any maintenance requirements defined in the approved data package as part of a continued airworthiness (approved system of) maintenance program approval or an equivalent program approved by CASA.

10.3 MAINTENANCE DOCUMENTS REQUIREMENTS

The following items should be reviewed as appropriate for RVSM maintenance approval:

- (a) Maintenance Manuals;
- (b) Structural Repair Manuals;
- (c) Standards Practices Manuals;
- (d) Illustrated Parts Catalogues;
- (e) Maintenance Schedule;
- (f) MMEL/Minimum Equipment List (MEL);
- (g) Maintenance Control Manuals; and
- (h) Equipment Lists/Wiring Diagram Manuals.

10.4 MAINTENANCE PRACTICES

If the operator is subject to an ongoing approved maintenance program, that program should contain the maintenance practices outlined in the applicable aircraft and component manufacturer's maintenance manuals for each aircraft type. The following items should be reviewed for compliance and if the operator is not subject to an approved maintenance program the following items should be followed:

- (a) all RVSM equipment should be maintained in accordance with the component manufacturer's maintenance requirements and the performance requirements outlined in the approved data package;

- (b) any modification, repair, or design change which in any way alters the initial RVSM approval, should be subject to a design review by persons approved by the approving authority;
- (c) any maintenance practices which may affect the continuing RVSM approval integrity, e.g. the alignment of pitot/static probes, dents, or deformation around static plates, should be referred to CASA or to persons delegated by CASA;
- (d) Built-In Test Equipment (BITE) testing is not an acceptable basis for system calibrations, (unless it is shown to be acceptable by the airframe manufacturer with CASA's agreement) and should only be used for fault isolation and troubleshooting purposes;
- (e) some aircraft manufacturers have determined that the removal and replacement of components utilising quick disconnects and associated fittings, when properly connected, will not require a leak check. While this approach may allow the aircraft to meet static system certification standards when properly connected, it does not always ensure the integrity of the fittings and connectors, nor does it confirm system integrity during component replacement and re-connections. Therefore, a system leak check or visual inspection should be accomplished any time a quick disconnect static line is broken;
- (f) airframe and static systems should be maintained in accordance with the airframe manufacturer's inspection standards and procedures;
- (g) to ensure the proper maintenance of airframe geometry for proper surface contours and the mitigation of altimetry system error, surface measurements or skin waviness checks should be made if needed to ensure adherence to the airframe manufacturer's RVSM tolerances. These tests and inspections should be performed as established by the airframe manufacturer. These checks should also be performed following repairs, or alterations having an effect of airframe surface and airflow;
- (h) the maintenance and inspection program for the autopilot should ensure continued accuracy and integrity of the automatic altitude control system to meet the height-keeping standards for RVSM operations. This requirement will typically be satisfied with equipment inspections and serviceability checks; and
- (i) where the performance of existing equipment is demonstrated as being satisfactory for RVSM approval, it should be verified that the existing maintenance practices are also consistent with continued RVSM approval integrity. Examples of these are:
 - (i) altitude alert;
 - (ii) automatic altitude control system;
 - (iii) ATC altitude reporting equipment; and
 - (iv) altimetry systems.

10.5 MAINTENANCE PRACTICES FOR NON-COMPLIANT AIRCRAFT

Those aircraft positively identified as exhibiting height-keeping performance errors which require investigation as specified in section 11.9 (paragraph 1) should not be operated in airspace where RVSM is applied until the following actions have been taken:

- (a) the failure or malfunction is confirmed and isolated by maintenance action; and
- (b) corrective action is carried out as required to comply with section 9.2.5(d)(vi) and verified to ensure RVSM approval integrity.

10.6 MAINTENANCE TRAINING REQUIREMENTS

New training requirements approved under regulation 214 (CAR 1988) will be introduced by the RVSM approvals processes. Areas that may need to be highlighted for initial and recurrent training maintenance personnel are:

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

10.7 TEST EQUIPMENT

10.7.1 General

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

10.7.2 Standards

Test equipment should be calibrated utilising reference standards whose calibration is certified as being traceable to the national standard. It should be calibrated at periodic intervals as agreed by the approving authority. The approved maintenance program should encompass an effective quality control program which includes the following:

- (a) definition of required test equipment accuracy;
- (b) regular calibrations of test equipment traceable to a master in-house standard. Determination of calibration interval should be a function of the stability of the test equipment. The calibration interval should be established on the basis of historical data so that degradation is small in relation to the required accuracy;
- (c) regular audits of calibration facilities both in-house and outside;
- (d) adherence to acceptable maintenance practices; and
- (e) procedures for controlling operator errors and unusual environmental conditions which may affect calibration accuracy.

11. RVSM OPERATIONAL APPROVAL

11.1 PURPOSE AND ORGANISATION

Section 6 described, in general terms, the administrative process which an Australian operator should follow to receive approval to operate an aircraft in RVSM airspace - the application, CASA evaluation of the application, and the granting of an approval to operate. Section 11 provides detailed information on the content of operational programs, practices and procedures, and on the operational approval process.

11.2 GENERAL

11.2.1 CASA Responsibilities

CASA must ensure that each operator can demonstrate that the operator's aircraft can maintain high levels of height-keeping performance.

CASA must be satisfied that operational programs are adequate. Flight crew training as well as operations manuals will be evaluated. Approval will be granted for individual Australian operators.

11.2.2 What an RVSM Operational Approval Covers

An *RVSM operational approval* covers not only the operator but also each individual aircraft group and each individual aircraft to be used by the operator in RVSM operations. Each aircraft must have received an *RVSM airworthiness approval* (from CASA) in accordance with section 9 or have a current *RVSM foreign airworthiness approval* before it will be listed on an operator's *RVSM operational approval*. (note: aircraft group is defined in section 9.2.2).

11.2.3 Worldwide Operations

It is important to note that aircraft that have been approved for RVSM can be used in RVSM operations worldwide. Aircraft equipage and altitude-keeping performance requirements were developed using the highest traffic counts in the world so that aircraft could receive a one-time approval for worldwide operations.

Operators that are starting RVSM operations in an RVSM area that is new to them must ensure that their RVSM programs incorporate any operations or continued airworthiness requirements unique to the new area of operations. This information is usually contained in guidance material for particular areas.

For details of operations in the Pacific see the FAA web site:

<www.faa.gov/ats/ato/rvsm_documentation.htm>

11.3 PRE-APPLICATION MEETING

A pre-application meeting should be scheduled between the operator and the Airline Operations Branch in Canberra. The purpose of the meeting is to inform the operator of CASA's expectations in regard to approval to operate in a RVSM environment. The content of the operator's RVSM application, CASA review and evaluation of the application, validation flight requirements, and conditions for removal of RVSM approval should be basic items of discussion.

11.4 CONTENT OF OPERATOR RVSM APPLICATION

The following sections describe the material which an operator applying for RVSM approval should provide to CASA for review and evaluation at least 60 days prior to the intended start of RVSM operations. A checklist of the documents required by CASA can be obtained from CASA's Airline Operations Branch, Canberra. An example of an operator's application can be found on the FAA web site.

11.4.1 Airworthiness Documents

Sufficient documentation should be available to show that the aircraft has been issued with an *RVSM airworthiness approval*.

- (a) In-service aircraft Documents that contain the inspections and/or modifications that are required to make an in-service aircraft RVSM compliant can take the form of approved Service Bulletins, Aircraft Service Changes, Supplemental Type Certificates or any other format that CASA finds acceptable;
- (b) In-production or new-production aircraft For such aircraft, statements of eligibility to conduct RVSM operations can be included in the AFM. Also, Type Certificate Data Sheets can be used to show RVSM eligibility by describing RVSM related avionics configurations and continued airworthiness criteria or providing reference to CASA approved documentation in the form of a report. Eligibility can be shown in any other format found acceptable to CASA.

In the case of a foreign registered aircraft with an *RVSM foreign airworthiness approval*, evidence should be produced to show that the approval is current.

11.4.2 Description of Aircraft Equipment

The applicant should provide a configuration list which details all components and equipment relevant to RVSM operations (section 8 discusses equipment for RVSM operations).

11.4.3 Operations Training Programs and Operating Practices and Procedures

Operators approved by CASA under regulation 217 (CAR 1988) should submit training syllabi and other appropriate material to CASA to show that the operating practices and procedures and training items related to RVSM operations are incorporated in initial and, where warranted, recurrent training programs (training for operations control or dispatch personnel should be included, where appropriate).

Private or General Aviation operators should demonstrate by means of written statements to CASA that their flight crews' knowledge of RVSM operating practices and procedures is sufficient to warrant the granting of an approval to conduct RVSM operations. That is, CASA:

- (a) may accept a training centre certificates (e.g. those from the Flight Safety Foundation in the US) without further evaluation;
- (b) may evaluate a training course prior to accepting a training certificate; and

- (c) may accept a statement in the operator's application that the operator will ensure that its pilots will be knowledgeable on RVSM procedures contained in Appendix 1; or
- (d) may accept a statement by the operator that it has or will conduct an in-house training program.

Practices and procedures in the following areas should be standardised using the guidelines of Appendix 1:

- (a) flight planning;
- (b) pre-flight procedures at the aircraft for each flight;
- (c) procedures prior to RVSM airspace entry;
- (d) in-flight procedures; and
- (d) flight crew training procedures.

Also, flight crew and, where applicable, operations control and flight dispatchers should be knowledgeable on contingency and other procedures unique to specific areas of operation.

11.4.4 Operations Manuals and Checklists

The appropriate manuals and checklists should be revised to include information/guidance on the standard operating procedures detailed in Appendix 1. Appropriate manuals should include a statement of the airspeeds, altitudes, and weights considered in RVSM aircraft approval to include identification of any operating restrictions established for that aircraft group (see section 7.3.4(c)). Manuals and checklists should be submitted for CASA review as part of the application process.

11.4.5 Past Performance

An operating history should be included in the application. The applicant should show any events or incidents related to poor height keeping performance which may indicate weaknesses in training, procedures, maintenance, or the aircraft group intended to be used.

11.4.6 Minimum Equipment List

A MEL, based on the MMEL, should include items pertinent to operating in RVSM airspace.

11.4.7 Maintenance

The operator should submit a maintenance program for approval in accordance with section 10 at the time the operator applies for operational approval.

11.4.8 Plan for participation in Verifications/Monitoring Programs

The operator should provide a plan for participation in the verification or monitoring program. This program should normally entail a check of at least a portion of the operator's aircraft by an independent height-monitoring system (see section 11.8 for further discussion of verification/monitoring programs).

11.5 CASA REVIEW AND EVALUATION OF APPLICATIONS

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

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

11.6 VALIDATION FLIGHT(S)

In some cases, the review of the RVSM application and programs may suffice for validation purposes. However, the final step of the approval process may be the completion of a validation flight. CASA Air Safety Auditors may accompany the operator on a flight through airspace where RVSM is applied to verify that operations and maintenance procedures and practices are applied effectively.

11.7 FORM OF AUTHORISING DOCUMENTS

11.7.1 Interim Approvals

Interim approvals issued prior to the promulgation of regulations 181A to 181X (CAR 1988) are no longer valid. CASA will automatically issue full approvals to those operators affected.

11.7.2 Full Approvals

Two approvals will be issued: an *RVSM airworthiness approval* and an *RVSM operational approval*. They may be issued at the same time, but an *RVSM operational approval* will only be issued if the *RVSM airworthiness approval* or *RVSM foreign airworthiness approval* are in force.

The approvals will take the form of a certificate and will identify the operator, each individual aircraft the approval covers, and any conditions on the approval (e.g. height monitoring program to be completed within a specified time of the approval being issued).

11.8 VERIFICATION/MONITORING PROGRAMS

11.8.1 General

A program to monitor or verify aircraft height-keeping performance is considered a necessary element of RVSM implementation for at least the initial area where RVSM is implemented. A height-monitoring system based on Global Positioning System (GPS) satellites or an earth-based system may fulfil this function. However, it is expected that most Australian operators will employ a GPS-based Monitoring System (GMS).

Verification/monitoring programs have the primary objective of observing and evaluating aircraft height-keeping performance to gain confidence that airspace users are applying the aircraft/operator approval process in an effective manner and that an equivalent level of safety will be maintained when RVSM is implemented.

11.8.2 Asia-Pacific Approvals Registry and Monitoring Organisation (APARMO)

The APARMO is the agency responsible for this function in the Asia-Pacific region. Current Pacific RVSM minimum monitoring requirements and information on GMS flights are detailed in Appendix 2.

It is anticipated that the necessity for such programs may be diminished or possibly eliminated after confidence is gained that RVSM programs are working as planned.

Monitoring can only be undertaken by an operator after CASA has issued an *RVSM airworthiness approval* for the aircraft or group of aircraft.

11.9 CONDITIONS FOR REMOVAL OF RVSM APPROVAL

11.9.1 Height-Keeping Errors and Operator Responsibilities

The incidence of height-keeping errors which can be tolerated in an RVSM environment is very small. It is incumbent upon each operator to take immediate action to rectify the conditions which caused the error. The operator should also report the event to CASA and Airservices Australia within 72 hours with initial analysis of causal factors and measures to prevent further events. The requirement for follow-up reports will be determined by CASA.

11.9.2 Types of Errors

Errors which should be reported and investigated are: TVE equal to or greater than ± 300 ft (± 90 m), ASE equal to or greater than ± 245 ft (± 75 m), and AAD equal to or greater than ± 300 ft (± 90 m).

Height-keeping errors fall into two broad categories: errors caused by malfunction of aircraft equipment and operational errors. An operator showing a history of errors of either variety may be required to forfeit approval for RVSM operations. If a problem is identified which is related to one specific aircraft type, the RVSM approval may be suspended/cancelled for that specific type.

11.9.3 CASA Actions

The operator should make an effective, timely response to each height-keeping error. CASA may consider suspending/cancelling an operator's RVSM operational approval if the operator's response to a height-keeping error is unsatisfactory. CASA will also 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, approval may be suspended until the root causes of these errors are shown to be eliminated and RVSM programs and procedures are shown to be effective.

The conditions under which RVSM approvals may be cancelled are detailed in regulations 181J and 181P (CAR (1988)).

Richard G. Yates
Assistant Director
Aviation Safety Standards

GLOSSARY OF TERMS

AAD	Assigned Altitude Deviation
AFM	Aircraft Flight Manual
APARMO	Asia Pacific Approvals Registry and Monitoring Organisation
ASE	Altimetry System Error
ATC	Air Traffic Control
AVE	Avionics Error
BITE	Built-In Test Equipment
CAAP	Civil Aviation Advisory Publication
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority
δ	Atmospheric Pressure Ratio
DFDR	Digital Flight Data Recorder
FAA	Federal Aviation Administration (of the United States)
FIF	Flight Information Form
FIR	Flight Information Region
FL	Flight Level
GPS	Global Positioning System (of the United States)
GMS	GPS-Based (Height) Monitoring System
GMU	GPS Monitoring Unit
hPa	Hectopascals
ICAO	International Civil Aviation Organization
in.Hg	Inches of Mercury
JAA	Joint Aviation Authorities (of Europe)
MASPS	Minimum Aviation System Performance Specification
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
M_{MO}/V_{MO}	Maximum Operating Limit Speed
MNPS	Minimum Navigation Performance Specification
NAT	North Atlantic (airspace)
OIF	Operator Information Form
QFE	Atmospheric pressure at aerodrome elevation (or at runway threshold)
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
RGCSPP	Review of the General Concept of Separation Panel
RSS	Root-Sum-Square
RVSM	Reduced Vertical Separation Minimum
SSE	Static Source Error
SSEC	Static Source Error Correction
SSR	Secondary Surveillance Radar
TC	Type Certificate
TVE	Total Vertical Error
VSM	Vertical Separation Minimum
W	Aircraft Weight

APPENDIX 1

TRAINING PROGRAMS 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 sections 2 to 6 of this appendix should be standardised and incorporated into training programs 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 carried out during the pre-flight procedure:

- (a) review technical logs and forms to determine the condition of equipment required for flight in 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; and

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

- (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 must be operating normally for entry into RVSM airspace:

- (a) two primary altitude measurement systems;
- (b) one automatic altitude-control system;
- (c) one altitude-alerting device; and
- (d) an operating transponder.

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.

NOTE: 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 must request a new clearance to avoid entering this airspace.

5. IN-FLIGHT PROCEDURES

5.1 GENERAL

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 1013.25 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 150 ft (45 m);

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

- (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 accomplished 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 ± 200 ft (± 60 m). 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 ± 300 ft (± 90 m) and/or an ASE greater than ± 245 ft (± 75 m) 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; and
- (j) if the pilot is notified by ATC of an assigned altitude deviation which exceeds ± 300 ft (± 90 m) then the pilot should take action to return to the cleared Flight Level as quickly as possible.

5.2 CONTINGENCY PROCEDURES AFTER ENTERING RVSM AIRSPACE

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.

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;

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

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

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.

The following information should be recorded when appropriate:

- (a) Primary and standby altimeter readings.
- (b) Altitude selector setting.
- (c) Sub-scale 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. Use of air data computer selector for fault diagnosis procedure.
- (f) The transponder selected to provide altitude information to ATC and any difference noted.

7. SPECIAL EMPHASIS ITEMS

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

- (a) knowledge and understanding of standard ATC phraseology used in each area of operations;
- (b) importance of crew members cross-checking each other to ensure that ATC clearances are promptly complied with;

- (c) use and limitations in terms of accuracy of stand-by 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 1 000ft (300m) planned separation during night conditions, when encountering local phenomena such as northern lights, for opposite and same direction traffic, and during turns;
- (e) characteristics of aircraft altitude capture systems which may lead to the occurrence of overshoots;
- (f) relationship between altimetry, automatic altitude control, and transponder systems in normal and abnormal situations; and
- (g) any airframe operating restrictions, if required for a specific aircraft group, related to an RVSM airworthiness approval.

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APPENDIX 2

ASIA-PACIFIC RVSM MINIMUM MONITORING REQUIREMENTS

[as of 5 October 2000]

1. INITIAL MONITORING

All Asia-Pacific operators that operate or intend to operate in airspace where RVSM is applied are required to participate in the RVSM monitoring program. The table of monitoring requirements shown below establishes requirements for initial monitoring associated with the RVSM approval process. In their application to the appropriate State authority for RVSM approval, operators must show a plan for meeting the applicable initial monitoring requirements.

2. AIRCRAFT STATUS FOR MONITORING

Aircraft engineering work required for the aircraft to receive RVSM airworthiness approval must be completed prior to the aircraft being monitored. Any exception to this rule will be coordinated with the State authority.

3. FOLLOW-ON MONITORING

Monitoring is an on-going program that will continue after the initial RVSM implementation phase. A follow-on sampling program for additional operator aircraft will be coordinated by the International Civil Aviation Organisation (ICAO) Asia-Pacific RVSM Implementation Task Force.

4. MONITORING OF AIRFRAMES THAT ARE RVSM COMPLIANT ON DELIVERY

If an operator adds new RVSM compliant airframes of a type for which it already has RVSM operational approval, providing the operator has completed monitoring requirements for the type in accordance with the table below, the new airframes are not required to be monitored, except as targeted at a later date in the follow-on sampling program. If an operator adds new RVSM compliant airframes of an aircraft type for which it has NOT previously received RVSM operational approval, then the operator should complete monitoring in accordance with the table below.

5. APPLICABILITY OF MONITORING FROM OTHER REGIONS

Monitoring data obtained in conjunction with monitoring programs from other regions can be used to meet Asia-Pacific monitoring requirements. The Asia-Pacific Approvals Registry and Monitoring Organisation (APARMO), which is responsible for administering the Asia-Pacific monitoring program, has access to monitoring data from other regions and will coordinate with States and operators to inform them on the status of individual operator monitoring requirements.

6. UPDATE OF MONITORING REQUIREMENTS TABLE AND WEB SITE

As significant data are obtained, monitoring requirements for specific aircraft types may change. When the table is updated, a letter will be distributed to States and operators. The updated table will be posted on the APARMO RVSM web site being maintained by the FAA on behalf of the ICAO Asia-Pacific regional planning group. The web site may be accessed as follows:

[<www.tc.faa.gov/act500/rvsm/aparmo_intro.html >](http://www.tc.faa.gov/act500/rvsm/aparmo_intro.html)

7. PRIOR RVSM EXPERIENCE

When a new-entrant-RVSM operator completes the regional monitoring requirements for State approval for all of its Pacific aircraft types or North Atlantic aircraft types, the operator is considered by APARMO to have “Prior RVSM Experience.”

For most aircraft types, monitoring is NOT required to be completed prior to operational approval being granted. SEE THE TABLE 1 BELOW.

TABLE 1

MONITORING NOT REQUIRED PRIOR TO THE GRANT OF RVSM APPROVAL, HOWEVER PARTICIPATION IN MONITORING IS REQUIRED IN ACCORDANCE WITH THIS CHART			
	CLASSIFICATION	AIRCRAFT GROUP	MINIMUM OPERATOR MONITORING FOR EACH AIRCRAFT TYPE
1	OPERATORS PLANNING TO CONDUCT OPERATIONS IN PACIFIC AIRSPACE <u>AND</u> OPERATORS WITH PRIOR RVSM EXPERIENCE PLANNING TO OPERATE IN THE WESTERN PACIFIC/SOUTH CHINA SEA AREA	New aircraft types from a manufacturer with a demonstrable track record of the production of MASPS compliant airframes or [A30B, A306], A310 (GE), A310 (PW), [A319, A320, A321], A330, A340, B717, [B721, B722] [B733, B734, B735] [B736, B737/BBJ, B738, B739] [B741, B742, B743, B74S] B744, [B752, B753], [B762, B763], B764 [B772, B773], DC10, MD11, MD80, L101 CL60, GLEX, GLF3, GLF4, GLF5 [F900, F900EX] FA50, FA50EX, F2TH, LJ60, H25B	Two airframes of each type* to be monitored as soon as possible but not later than 6 months after the issue of RVSM operational approval. <i>* Note. For the purposes of the minimum monitoring requirement, aircraft within parenthesis [] may be considered as the same type.</i>
Category 2 below has been adopted in preparation for RVSM implementation in the Western Pacific/South China Sea Area on 21 Feb 2002			
2	OPERATORS WITHOUT PRIOR RVSM EXPERIENCE WHOSE OPERATIONS ARE PRIMARILY IN THE WESTERN PACIFIC/SOUTH CHINA SEA AREA	Same types as above in section 1.	At least 3 airframes of each type unless operator has only 1 or 2 of a type, then all operator airframes of that type should be monitored. Monitoring to be completed as soon as possible but not later than 3 months after the issue of RVSM operational approval or not later than 3 months after the start of Western Pacific/South China Sea RVSM operations, whichever occurs later.
MONITORING REQUIRED PRIOR TO THE GRANT OF RVSM APPROVAL			
3	OPERATORS OF AIRCRAFT TYPES SHOWN IN THE BLOCK TO THE RIGHT	Other group or non –group aircraft other than those listed above including: A124, ASTR, B707, B731, B732, C525, C560, C650, C750, DC8, DC9, E145, FA10, FA20, F100, GLF2, GALX, H25A, H25C, IL62, LJ31, LJ35, LJ55, MD90 or new aircraft types from a manufacturer without a demonstrable track record of the production of MASPS compliant airframes.	60% of target number of airworthiness approved, same type, airframes of each operator to be monitored or individual monitoring of airworthiness approved airframes of a given operator.

8. GPS-BASED MONITORING SYSTEM (GMS) MONITORING PROCEDURES

8.1 GENERAL

Monitoring is required for all operators of aircraft that have received RVSM operational approval. Current monitoring goals should be reviewed for actual requirements; generally 2 or 3 aircraft of each type must be monitored. Monitoring requirements as well as other RVSM information can be found at the following web sites:

FAA RVSM

<<http://www.faa.gov/ats/ato/rvsm1.htm>>

Asia-Pacific Approvals Registry and Monitoring Organization (APARMO)

<http://www.tc.faa.gov/act500/rvsm/aparmo_intro.html>

8.2 AIRWORTHINESS APPROVAL

In-production or new production aircraft attain airworthiness approval through verification of RVSM eligibility in the Aircraft Flight Manual or Type Certificate Data Sheet. In-service aircraft attain airworthiness approval through the application of the type-specific RVSM Service Bulletin. The aircraft engineering requirements vary for individual types or groups of aircraft. These requirements may include upgrades to the air data computers, pitot-static modifications, skin waviness testing, and visual or paint inspections. After airworthiness approval is obtained, the operational approval process is completed by incorporation of RVSM policy and procedures into the training program, manuals, and maintenance program. **Monitoring may be conducted after airworthiness approval information has been sent to the APARMO. Only airworthiness approved aircraft will be monitored.**

8.3 APARMO

The APARMO is responsible for all monitoring activity and the operation of the GMS. CSSI Inc., the GMS support contractor, will assist the APARMO with the monitoring program.

8.4 GMS DESCRIPTION

The GMS is comprised of the equipment and procedures to collect and process three required data elements: GPS data, pressure altitude or Mode C data, and meteorological data. The GPS-based Monitoring Unit (GMU) is used to collect the GPS data during the monitoring flight. The APARMO, through the use of the attached Flight Information Form (FIF), will coordinate with the operator the collection of pressure altitude or Mode C data from ATC facilities. The operator will provide pressure altitude data from the Digital Flight Data Recorder (DFDR) of the aircraft being monitored. Late transmittal of the FIF and illegible or blank entries will delay processing and the dissemination of results. Meteorological data will be obtained by the APARMO without operator involvement.

8.5 MONITORING FLIGHTS

Monitoring flights do not need to be conducted in Pacific airspace. Monitoring can be conducted on scheduled flights, ferry flights, or monitoring-specific flights. To ensure collection of sufficient position data, the flight must be straight and level at any altitude from FL 290 to FL 410, and should be at least thirty minutes in duration. Monitoring should also be conducted in areas where Mode C radar data can be retrieved in a timely manner. In addition to Mode C data collected by the APARMO, the operator should provide pressure altitude data from the DFDR to the APARMO for Altimetry System Error (ASE) calculation.

8.6 GMU DESCRIPTION

The GMU is a portable unit comprised of a Global Positioning System (GPS) receiver, two GPS antennas, temporarily mounted on interior windows, and a laptop computer. The unit requires plug in power from the aircraft (draws 2.0 to 4.0 amperes maximum) and accepts multiple types of power standard to aircraft. The GMU can be installed in the aircraft cockpit or cabin, depending upon aircraft type. Installation time is approximately 15 minutes. For most transport aircraft, the GMU is best installed using the aft cockpit windows. The GMS Monitoring Specialist typically occupies a jump seat to monitor GMU performance. GMU installation is transparent to crew operations.

8.7 MONITORING PROCESS

Upon receiving airworthiness approval, the operator should contact the APARMO GMS Operations Coordinator to discuss monitoring options. To start the monitoring process the operator should submit the attached Monitoring Application to the APARMO. The Monitoring Application should include all aircraft that will be operated in the Pacific Region. The collection of GPS data with the GMU can be accomplished by a GMS Monitoring Specialist or by an operator representative that has received GMU training. The operator and the APARMO GMS Operations Coordinator will develop a mutually agreed upon plan for monitoring.

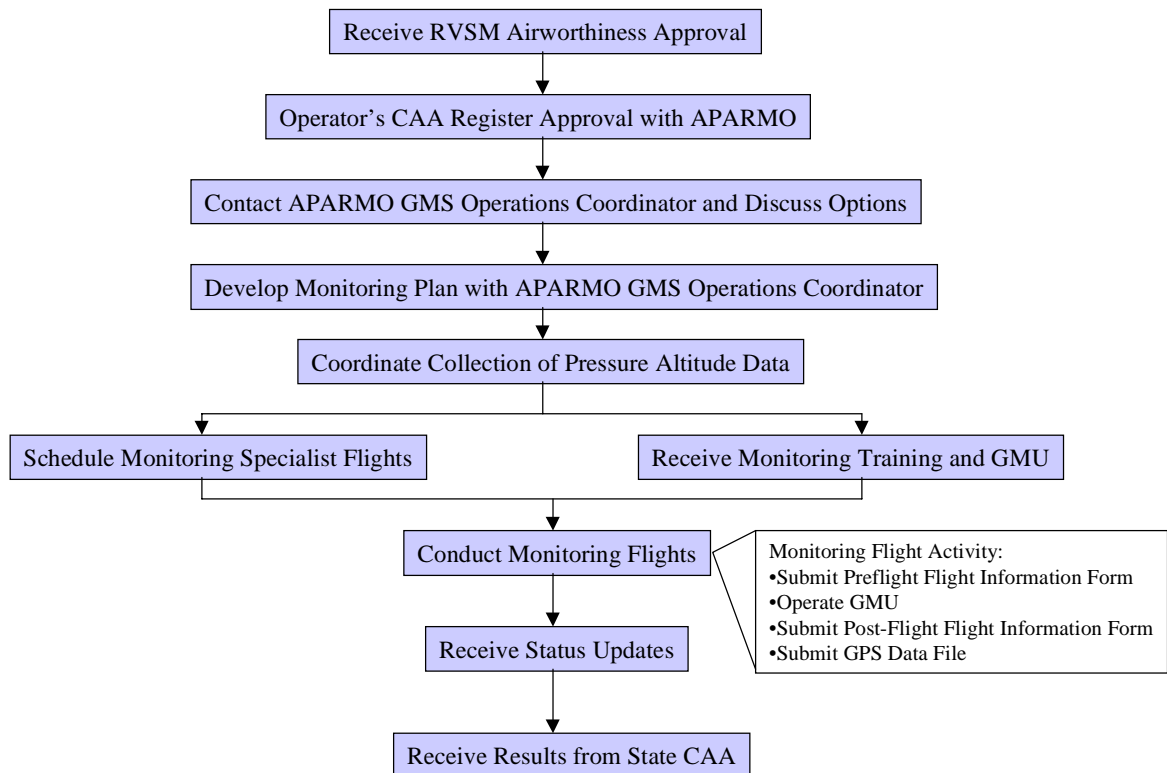
The operator will take the necessary steps to retrieve pressure altitude data from the DFDR. The DFDR data should be sent to the APARMO as an electronic file. The specific format of the electronic file and the APARMO DFDR point of contact is contained in the following section.

To conduct the monitoring flight, the Monitoring Specialist or operator representative that has received GMS training, will perform the following tasks:

- Submit pre-flight FIF to APARMO and GMS Support Contractor
- Operate GMU
- Submit post-flight FIF to APARMO and GMS Support Contractor
- Submit GPS data files to GMS Support Contractor

The Monitoring process from the operator's perspective is illustrated in Figure 1. The operator will be notified by a facsimile memo as the FIF, GPS data file, and pressure altitude data file move through the post-flight processing steps at the APARMO.

Figure 1. Monitoring Process For Aircraft Operators



8.8 DIGITAL FLIGHT DATA RECORDER DATA

DFDR data should contain altitude (ALT) expressed in feet with corresponding time (UTC) expressed in hours, minutes, and seconds HH/MM/SS to two decimal places and the aircraft transponder code (TXP). Altitude data submitted to the APARMO should have reports with 12-second or better intervals.

Providing aircraft position data for each level of flight further aids the APARMO in ASE calculation. Position data can be provided in latitude/longitude or range/azimuth (x/y) formats. A reference point is helpful when providing position data in the range/azimuth (x/y) format. Provide the units of measurement for each piece of position data submitted to the APARMO.

DFDR Data Samples

Range/Azimuth (X/Y) Data

TXP	X	Y	ALT	HH/MM/SS
5113	-284.969	197.938	36900	13/23/21.00

Latitude/Longitude Data

TXP	LAT	LON	ALT	HH/MM/SS
2241	54.833	4.494E	28000	17/57/42.00
2241	54.826	4.489E	28000	17/57/47.00

Sending DFDR data to the APARMO as an ASCII or text file via e-mail is recommended.

APARMO DFDR Point of Contact

Phone: +1 609 485 5102

Fax: +1 609 485 5117

E-mail: Anthony.Strazzeri@faa.gov

If e-mail is not available, the operator should send DFDR files on PC-formatted 3.5" diskettes to:

Anthony Strazzeri

FAA William J. Hughes Technical Center

ACT-520

Atlantic City Airport, NJ 08405

8.9 MONITORING POST-FLIGHT INFORMATION

After completion of the monitoring flight, the GPS data will be processed by the GMS Contractor and forwarded to the APARMO. The operator will be advised by fax of the processing status of the data file. For the computation of the ASE, Meteorological data and Mode C data will be collected and merged with the GPS data at the APARMO. Final ASE results should be available from the APARMO within three weeks of the flight. The results will be sent to the State Airworthiness Authority and posted on the APARMO web site.

APARMO GMS Contacts

APARMO Activities Coordinator

Phone: +1 609 485 5334
Fax: +1 609 485 5078
Email: aparmo@tc.faa.gov

CSSI Inc., APARMO GMS Operations Coordinator

Phone: +1 202 863 2175
Fax: +1 202 863 2398
Email: monitor@cssiinc.com

**REDUCED VERTICAL SEPARATION MINIMUM (RVSM)
MONITORING APPLICATION**

(Return completed form by fax to +1 609 485 5078 and +1 202 863 2398)

Operator Name: _____

Address: _____

Operator Primary Point of Contact

Name: _____ Title: _____

Telephone Number: _____ Fax Number: _____

Email Address: _____

Secondary Point of Contact

Name: _____ Title: _____

Telephone Number: _____ Fax Number: _____

Email Address: _____

Civil Aviation Safety Authority Contact

Name: _____ Title: _____

Telephone Number: _____ Fax Number: _____

Email Address: _____

PLEASE PROVIDE THE AIRCRAFT INFORMATION SHOWN OVER

FLIGHT INFORMATION FORM (FIF)

**Please Fax to the APARMO at +1 609 485 5078 and +1 202 863 2398,
24 hours prior to flight and within 6 hours of landing.**

APARMO USE

INFORMATION TO BE RECORDED PRIOR TO FLIGHT

Airline/Operator:		GMU Container Number:	
Point of Contact for Operator:			
Name:		Phone:	Fax:
Aircraft Type/Series:		Aircraft Registration Number:	
Call Sign:		Airframe Serial Number:	
Planned: Origin:	Departure Date (UTC):	Departure Time (UTC):	
Planned: Destination:	Arrival Date (UTC):	Arrival Time (UTC):	
Installer (Name/Org.):		Retriever (Name/Org.):	
Mode S Equipped (Yes/No):		Separation Between Mounted Antennas (ft.):	
Installer/Operator Comments:			

INFORMATION TO BE RECORDED BY FLIGHT CREW/GMU OPERATOR

Data Collection:	Start Date (UTC):	Start Time (UTC):
GMU File Name:		
Departure Time (UTC):		Origin (ICAO ID):
Please record the requested information as soon as practical when:		
1. Aircraft is first established in level flight at or above FL 290, or		
2. The ATC assigned transponder code is changed at or above FL 290, or		
3. There is a flight level change and aircraft remains at or above FL 290, or		
4. An autopilot change is initiated at or above FL 290, or		
5. The ARTCC or FIR changes.		

Time (UTC)	Assigned FL	Mach/Air Speed	Xpndr Code/Source	Altimeter Reading		Autopilot (L, R, C)		FMS/PMS (Y/N)	ARTCC/FIR (ICAO ID)
				Pilot	Co-pilot	Pilot	Co-pilot		

Data Collection:	End Date (UTC):	End Time (UTC):
Arrival Time (UTC):		Destination ICAO (ID):

Comments on flight conditions affecting height keeping performance, i.e. turb, and location

