



Advisory Circular

AC91-4

Reduced Vertical Separation Minima (RVSM)

Initial Issue

01 July 2002

GENERAL

Civil Aviation Authority Advisory Circulars (AC) contain information about standards, practices and procedures that the Director has found to be an Acceptable Means of Compliance (AMC) with the associated rule.

An AMC is not intended to be the only means of compliance with a rule, and consideration will be given to other methods of compliance that may be presented to the Director. When new standards, practices or procedures are found to be acceptable, they will be added to the appropriate Advisory Circular.

PURPOSE

This Advisory Circular provides methods, acceptable to the Director, for showing compliance with operations in RNP airspace requirements of Part 91 and explanatory material to assist in showing compliance.

RELATED CAR

This AC relates specifically to Civil Aviation Rules 91.247 and 91.519.

CHANGE NOTICE

There was no previous issue of this AC, consequently no change is in effect.

Introduction

Reduced vertical separation minimum (RVSM) was implemented in the North Atlantic (NAT) Region on 27 March 1997. RVSM was implemented in selected areas of the Pacific and Mid-Asia regions on 24 February 2000.

Annex 2 of the ICAO Convention and ICAO Doc 7030 provide the requirements for RVSM operations in the selected areas.

The intention of this advisory circular is to provide—

- information on the implementation plan
- information on the approvals process
- guidance on the arrangements and need for monitoring
- guidance on how further information can be obtained

Table of Contents

1	List of Acronyms	2
2	List of Definitions	2
	Aircraft type groupings.....	3
	Altimetry system error (ASE).....	3
	Non-compliant aircraft.....	3
	Target level of safety (TLS).....	3
3	Reduced Vertical Separation Minimum (RVSM)	3
3.1	Background.....	3
3.2	VSM implementation planning.....	4
3.2.1	North Atlantic Region.....	4
3.2.2	Pacific and Mid-Asia Regions.....	4
4	Schedule for phased implementation and airspace dimensions	5
4.1	North Atlantic Region.....	5
4.2	Pacific and Mid-Asia Regions.....	5
5	RVSM approvals process	5
5.1	North Atlantic Region.....	5
5.2	Pacific and Mid-Asia Regions.....	7
6	Height Monitoring	8
6.1	North Atlantic Region.....	8
6.2	Pacific and Mid-Asia Regions.....	9
7	Further Information	11
	APPENDIX 1 —	12
	Coordination to use a Global Positioning System (GPS) Monitoring Unit (GMU)	12

1 List of Acronyms

AC	Advisory Circular
APARMO	Asia-Pacific Approvals Registry and Monitoring Organization
ASE	altimetry system error
ATC	air traffic control
CMA	central monitoring agency
CTA	control area
FAA	Federal Aviation Administration
FL	flight level
GMU	global positioning system monitoring unit
GMS	global positioning system monitoring system
GPS	global positioning system
HMU	height monitoring unit
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Airline Pilots Associations
IFATCA	International Federation of Air Traffic Controllers Associations
JAA	Joint Airworthiness Authorities
MASPS	minimum aircraft system performance specification
MNPS	minimum navigation performance specification
MNPSA	minimum navigation performance specification airspace
NAT	North Atlantic
NAT SPG	North Atlantic Systems Planning Group
PAC	Pacific (incorporates the Pacific and Mid-Asia regions as defined in ICAO Doc 7030/4)
RGCSPP	Review of the General Concept of Separation Panel
RVSM	reduced vertical separation minimum of (300m) 1000 ft between flight levels
TLS	target level of safety
VSM	vertical separation minimum

2 List of Definitions

The following definitions are intended to clarify certain specialized terms used in this AC.

Aircraft type groupings.

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

Altimetry system error (ASE).

The difference between the altitude indicated by the altimeter display (assuming a correct altimeter barometric setting) and the pressure altitude corresponding to the undisturbed ambient pressure.

Non-compliant aircraft.

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

Target level of safety (TLS).

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

3 Reduced Vertical Separation Minimum (RVSM)

3.1 Background

In 1982 the International Civil Aviation Organisation (ICAO) initiated a series of world-wide studies to assess the feasibility of a reduction of the Vertical Separation Minimum (VSM) above FL 290 from 2000 ft to 1000 ft. The studies were co-ordinated by the Review of the General Concept of Separation Panel (RGCSP) that included representation from the International Air Transport Association (IATA), International Federation of Airline Pilots Associations (IFALPA) and the International Federation of Air Traffic Controllers Associations (IFATCA). The principal benefits which the implementation of the reduced VSM were expected to provide were—

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

Studies and data collections were conducted in Canada, Japan, USA, USSR and four Member States of Eurocontrol: France, Germany, Netherlands and United Kingdom. These studies were essentially intended to determine the following—

- the height keeping accuracy of the current aircraft population at/above FL 290
- the causes of height deviations > 300 ft and to define corrective measures
- the basis of a future Minimum Aircraft System Performance Specification (MASPS) to support the use of a 1000 ft vertical separation above FL 290

As a result, the RGCSP concluded that a 1000 ft VSM between FL 290 and FL 410 was technically feasible without imposing unreasonably demanding technical or operational requirements. The ICAO Air Navigation Commission endorsed these findings in 1990.

The North Atlantic (NAT) was identified as the region best suited to the first application of the new minimum because of the better than average height keeping accuracy shown by NAT Minimum Navigation Performance Specifications (NAT MNPS) approved aircraft, together with the predominantly one-way traffic flow in the NAT Region.

On 27 March 1997 RVSM was introduced in the NAT for flight levels 330 - 370 inclusive. On 8 October 1998, the NAT RVSM airspace was expanded to include flight levels 310 -390. The NAT RVSM region is defined

as—

the MNPS airspace being that portion of the NAT Regions airspace extending between latitude 27°N and the North Pole, bounded in the East by the Eastern boundaries of the control areas (CTA) Santa Maria Oceanic, Shanwick Oceanic and Reykjavik and in the West by the Western boundary of New York Oceanic excluding the area west of 60°W and south of 38° 30N.

The Pacific RVSM Task Force has been meeting to evaluate and implement RVSM in the Pacific and Mid-Asia regions. The Task Force proposed the implementation of RVSM in the regions on 24 February 2000. Accordingly, additional areas became RVSM exclusive airspace on 24 February 2000. The following States will individually promulgate these areas:

- Australia
- Fiji
- New Zealand
- Tahiti
- United States of America
- Japan
- Papua New Guinea

3.2 VSM implementation planning

3.2.1 North Atlantic Region

Extensive detailed implementation planning took place to ensure the safe introduction of RVSM in the NAT Region. The work involved was delegated by the NAT SPG to a number of its sub-groups. The effort culminated in the production of NAT Doc 002, Guidance Material on the Implementation of a 300 m (1000 ft) Vertical Separation Minimum in the Minimum Navigation Performance Specifications Airspace (MNPSA) of the North Atlantic Region (first edition, July 1994). This document was distributed by the ICAO European and North Atlantic Office in Paris and is constantly being revised to include changes to the RVSM implementation plan.

The main body of NAT Doc 002 provides detailed information on operation of the NAT RVSM airspace, together with associated airworthiness requirements, State procedures, ATC considerations, and system performance monitoring. In addition, an Appendix to the document provides 'FAA Interim Guidance Material on the Approval of Operators/Aircraft for RVSM Operations'. This Appendix contains detailed MASPS information that will be published by the FAA as an Advisory Circular (AC) and by the JAA as Advisory Material Joint (AMJ) once administrative and legal procedures have been completed.

The material contained in NAT Doc 002 is intended to complement the information contained in NAT Doc 001/TI3.5N/6, ICAO Guidance and Information Material concerning Air Navigation in the North Atlantic (NAT) Region, sixth edition 1992, and in the North Atlantic MNPS Airspace Operations Manual, sixth edition 1993. It has been set out in a format which will allow the relevant parts to be assimilated in future editions of either, or both, of the existing guidance documents.

3.2.2 Pacific and Mid-Asia Regions

A significant amount of the guidance information published for the implementation of RVSM in the NAT region is also applicable in the PAC region. Specific documentation for Pacific and Mid-Asia RVSM operations has been produced by the Pacific RVSM Task Force: The Guidance Material on the Implementation of a 300m (1000ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Pacific Region.

Other guidance documents are available at the following FAA website:
http://www.faa.gov/ats/ato/pacific_rvsm.htm

4 Schedule for phased implementation and airspace dimensions

4.1 North Atlantic Region

To implement the full range of RVSM levels between FL 290 and FL 410 inclusive, it was originally conceived that the vertical dimensions of NAT MNPS airspace would be changed to a lower limit of FL 285 and an upper limit of FL 420. However, when it became apparent that there would be insufficient approved airframes to justify the full use of these levels from the original start date of the RVSM trial, it was decided to adopt a phased approach and also to delay the date of commencement. By this action, both RVSM approved and non-RVSM approved aircraft could be accommodated in MNPSA for an interim period.

Phase 1 of the implementation process commenced as an operational trial of 1000 ft VSM between FL 330 and FL 370 inclusive on 27 March 1997. Phase 2 began on 8 October 1998 and extended the RVSM levels to between FL 310 and FL 390. Phase 3 will extend RVSM levels from FL 290 to FL 410 and will be implemented according to demand.

The decision on whether to proceed with the last phase of the implementation schedule will be taken by the NAT IMG.

4.2 Pacific and Mid-Asia Regions

The Guidance Material on the Implementation of a 300m (1000ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Pacific Region indicates that there will be three phases of RVSM implementation in the PAC region: verification, trial and operational. The Pacific RVSM Task Force has decided not to proceed with a phased implementation schedule and RVSM will be fully (operational phase) introduced on 24 February 2000 between FL 290 and FL 410.

5 RVSM approvals process

5.1 North Atlantic Region

Aircraft operating within existing MNPS airspace are currently required to meet a minimum navigation performance specification in the horizontal plane through the mandatory carriage and use of a specified level of navigation equipment which has been approved by the State of Registry, or State of the Operator, for the purpose. These requirements are set out in NAT Doc 001/T13.5N/6 and in the NAT MNPS Airspace Operations Manual. For the purposes of RVSM, the following terminology has been adopted—

- (1) RVSM (Airworthiness) Approval: The approval that is issued by the CAA to indicate that an aircraft has been modified in accordance with the relevant approval documentation e.g. service bulletin, supplemental type certificate etc. and is therefore, eligible for monitoring. The date of issue of such an approval should coincide with the date when the modification was certified by the operator as being complete.
- (2) RVSM (Operational) Approval: The approval that is issued by the CAA once an operator has achieved the following—
 - RVSM Airworthiness approval
 - State approval of operations manual (where applicable) and on-going maintenance procedures

Only once RVSM (operational) approval has been issued should "W" be used in item 10 of the ATC flight plan to indicate RVSM approval.

One of the RGCSP conclusions regarding implementation of RVSM was that system operations should be monitored. Therefore, during the period prior to Phase 1, the monitoring of airworthiness approved aircraft took place within the existing 2000 ft VSM airspace.

To facilitate safely the phased introduction of RVSM, it was necessary to review the monitoring requirements. In the course of this review, it was decided that the introduction of a requirement for the monitoring of aircraft height keeping performance must be included in the approval process. The modified process calls for States to pass, to the NAT Central Monitoring Agency (CMA), details of aircraft that have been issued with RVSM airworthiness approval. An aircraft with RVSM airworthiness approval becomes eligible for monitoring from the date of issue of its approval.

When, through monitoring, an operator has demonstrated acceptable height keeping performance by its fleet of the same type of aircraft, the CMA will inform the CAA so that the CAA may grant RVSM approval for that particular fleet. The modified process for approval of group aircraft is as follows—

- (1) For Papua New Guinea registered aircraft, the Civil Aviation Authority of Papua New Guinea will evaluate RVSM airworthiness approval documents for group aircraft, including—
 - service bulletins:
 - supplemental type certificates.
- (2) Operators inspect and/or modify aircraft in accordance with the appropriate airworthiness approval document.
- (3) Operators provide the CAA with data of all aircraft that they intend to operate in RVSM, airspace as well as any documentation that may be required for those aircraft that have been inspected and/or modified in accordance with the RVSM airworthiness documents, including—
 - aircraft type and series:
 - registration number:
 - manufacturer's serial number:
 - aircraft Mode S address code in hexadecimal format.
- (4) Operators obtain CAA agreement to their on-going maintenance procedures, their operations manual, where applicable, training programmes, and complete monitoring requirements as required.
- (5) The CMA informs the CAA regarding the completion of monitoring requirements by each operator.
- (6) On completion of the above steps, the CAA grants RVSM operational approval.

An aircraft will not be permitted to fly in NAT RVSM airspace until RVSM operational approval has been granted.

- (7) The CAA will notify the Central Monitoring Agency (CMA) as soon as possible, using a CMA Form 2 or by electronic means direct from their approvals database which should be set up in accordance with CMA recommendations. The notification will include the:
 - state of registry of the aircraft:
 - name of the operator:
 - state of the operator:
 - aircraft type:
 - aircraft series:

- aircraft serial number:
 - registration marks:
 - Mode S address code:
 - date of RVSM airworthiness approval:
 - date of RVSM operational approval.
- (8) The date of airworthiness approval issued by the CAA should be the actual date that the modifications/inspection were completed for each airframe.
- (9) After the CAA has granted an RVSM approval, operators take steps to either overfly the HMUs near Strumble or Gander, or arrange for the carriage of a GMU. If monitoring occurs before the CAA has informed the CMA, the accrued data may still be used provided that it is dated after the modification or inspection was completed. In the case of aircraft added to an operator's fleet of the same type, after initial application for RVSM operating authority, the CMA will determine whether any further monitoring is required and will inform the CAA, which in turn, should inform the operator. If more monitoring is required, operators should comply with the provisions of this advisory circular.
- (10) The CMA is responsible for determining whether an operator's fleet has demonstrated acceptable height keeping performance. Operators can consult the ARINC Bulletin Board or the CMA to ascertain that its aircraft have been monitored and acceptable performance has been demonstrated.

Note: Acceptable height keeping performance will be based on the ASE measurements resulting from a target sample of 60% of aircraft of each type from each operator. An 80% target will apply for IGA group aircraft. Based on the ASE results, these targets can be reduced or increased depending on whether a sufficient number of aircraft have been sampled to demonstrate that the Target Level of Safety will be met with a high degree of confidence. Additionally, no individual airworthiness approved aircraft should be non-compliant.

Note: Group aircraft means aircraft that are of nominally identical design and build with respect to all details that could influence the accuracy of height keeping performance.

In summary, for Papua New Guinea registered group aircraft to be approved for NAT RVSM operations it is required to—

- obtain airworthiness approval i.e. be MASPS compliant:
- obtain RVSM approval from the CAA:
- demonstrate acceptable height keeping performance through monitoring (within six months of being granted RVSM operational approval).

In the case of non-group aircraft, the preceding procedures do not apply. Operators of these aircraft must apply for their operating authority individually. Monitoring by an HMU or GMU is a pre-requisite to obtaining RVSM operational approval unless flight test evidence can be provided to the CAA to show that each airframe is compliant with ASE targets. In the latter event, the CAA has been requested to forward ASE data to the CMA for inclusion in the safety analysis.

5.2 Pacific and Mid-Asia Regions

The process for obtaining an RVSM approval for the PAC region is the same as that outlined for the NAT region. Details on the application requirements are contained in The Guidance Material on the Implementation of a 300m (1000ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Pacific Region.

6 Height Monitoring

6.1 North Atlantic Region

The introduction and continued operation of the 1000 ft RVSM in the NAT MNPS airspace is conditional upon the over-riding consideration that the risk of collision as a consequence of a loss of vertical separation, from any cause, is less than the agreed target level of safety (TLS) of 5×10^{-9} fatal accidents per flight hour. Accordingly, the NAT SPG agreed, in January 1994, that monitoring would be carried out using a hybrid system comprising—

- (1) two fixed ground-based Height Monitoring Units (HMUs) located at—
 - Gander, Canada
 - Strumble, United Kingdom
- (2) a GPS-based monitoring system comprising—
 - portable GPS monitoring units (GMUs)
 - GPS reference stations
 - post-flight processing facilities
 - logistic support

Specifically, the total monitoring system has been designed to provide—

- guidance on the efficacy of the MASPS and on the effectiveness of altimetry system modifications
- confidence that the TLS will be met
- further evidence of the stability of altimetry system error (ASE)

Note: ASE stability is a premise around which the monitoring system has been designed.

Both production model HMUs are expected to be fully operational by December 1997. In the interim, monitoring is being achieved using a single pre-production HMU situated near Strumble, together with approximately 45 GMUS. Those aircraft that will seldom or never overfly the HMU will be monitored using a GMU. To obtain current monitoring procedures operators should contact the Aircraft Certification Unit at the CAA.

6.2 Pacific and Mid-Asia Regions

In the PAC region, it is not anticipated that an HMU type fixed location system will be available. Thus, the advantages of the hybrid monitoring system are compromised. Although the fleet size of operators and aircraft types indicates that the monitoring goals census should be achievable with the GMS, some of the features of the HMU would need to be incorporated into the GMS. They include but are not limited to, the following:

- repeat measurement of airframes to assure stability of ASE
- continued monitoring of aircraft to assure that compliant height-keeping performance is maintained
- continued assurance that the risk in the system is maintained at a level below the TLS

Initial Monitoring: All 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 the initial phase of Pacific RVSM implementation. In their application to the CAA for RVSM approval, operators must show a plan for meeting the applicable initial monitoring requirements.

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.

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 co-ordinated by the Pacific RVSM Implementation Task Force.

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.

Applicability of North Atlantic Monitoring: Monitoring data obtained in conjunction with the NAT RVSM monitoring program can be used to meet Pacific monitoring requirements. The Asia/Pacific Approvals Registry and Monitoring Organization (APARMO) which is responsible for administering the Pacific monitoring program has access to NAT monitoring data and will coordinate with States and operators to inform them on the status of individual operator monitoring requirements.

Update of Monitoring Requirements Table and Website: As significant data is 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 RVSM website being maintained by the FAA on behalf of the ICAO Pacific/Asia regional planning group.

For most aircraft types, monitoring is NOT required to be completed prior to operational approval being granted. see the table below.

Monitoring not required prior to the grant of RVSM approval			
	Classification	Aircraft Group	Minimum operator monitoring for each aircraft type
1	Operators with prior RVSM experience	New aircraft types from a manufacturer with a demonstrable track record of the production of MASPS compliant airframes - OR any of the following types: A300 B2/B4, A300-600, A310 (GE), A310 (PW), A319/321, A320, A330, A340, B-727, B737-300/400/500, B737-600/700/800, B747 100/200/300/SP, B747-400, B757, B767-200, B767-300, B777, CL60, DC10, FALCON 900/EX, GULF G4, LJ 60, L1011, MD11	at least TWO airframes unless operator has only one of a type, than ONE airframe - monitoring to be completed as soon as possible but no later than within 6 months after the issue of RVSM operational approval or the start of Pacific RVSM operations whichever occurs later.
2	Operators without prior RVSM experience	Same types as above in section 1	at least THREE airframes unless operator has only 1 or 2 of a type, than all operator airframes of that type - monitoring to be completed as soon as possible but not later than within 3 months after the issue of RVSM operational approval or the start of Pacific RVSM operations whichever occurs later.
3	All operators of aircraft that are expected to meet reduced monitoring requirements	FALCON 50/EX, FALCON 2000, HS 25 B/C	60% of target number of RVSM approved airframes OR individual monitoring of RVSM approved airframes - monitoring to be completed as soon as possible but no later than within 3 months after the issue of RVSM operational approval or the start of Pacific RVSM operations whichever occurs later.
Monitoring required prior to the grant of RVSM approval			
4	Insufficient data on approved aircraft	Other group or non-group aircraft not listed in above 3 sections 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 airframes OR individual monitoring of airworthiness approved airframes to be completed prior to the issue of RVSM operational approval

7 Further Information

Information on the RVSM programme is available through the Internet by addressing the ARINC bulletin board on <http://www.arinc.com> and calling up the RVSM pages. Aircraft that are successfully monitored by the NAT CMA will be promulgated via the bulletin board. Operators will be notified by fax or phone of individual access codes on the first occasion that its aircraft are placed on the board. More information may be obtained from—

Ms Jean Gingrich
ARINC
USA

Phone: 001 (410) 266-4562
Facsimile: 001 (410) 573-3007

Further information on policy, planning and implementation issues for RVSM can be obtained from:

- for the NAT region—

National Air Traffic Services Ltd
Central Monitoring Agency
Room T805
CAA House
45-59 Kingsway
London WC2B 6TE

Phone: 0044 0171-832-5732
Facsimile: 0044 0171-832-5562

- for the PAC region—

Asia-Pacific Approvals Registry and Monitoring Organization (APARMO)
William J Hughes Technical Centre (WJHTC)
NAS & International Airspace Analysis Branch (ACT-520)
Atlantic City International Airport
Atlantic City NJ 08405
USA

Phone: 001 (609) 485-5475
Fax: 001 (609) 485-5117
E-Mail: APARMO@tc.faa.gov

APPENDIX 1 — Coordination to use a Global Positioning System (GPS) Monitoring Unit (GMU)

Procedures to follow in order to obtain a GMU for monitoring—

- (1) Confirm that the aircraft is airworthiness approved by the CAA and that the information has been forwarded to the Central Monitoring Agency (CMA).
- (2) Contact Mr. H. Sell at ARINC on 001 (410) 266-4931.
- (3) Decide who will accomplish the data collection - the operator or ARINC.
- (4) If the operator accomplishes its own data collection—
 - ARINC will arrange the date for staff specialists to deliver the GMU(s) and conduct the training
 - the operator and ARINC will execute a property custody agreement
 - the operator will fax a flight information form to the Federal Aviation Administration Technical Centre (FAATC) and ARINC as soon as possible after each flight
- (5) If ARINC accomplishes the data collection—
 - the operator will provide ARINC with flight/maintenance schedules and flight data
 - ARINC provide the operator with a collection schedule
- (6) Once data collection is complete (if done by the operator), arrange for return of the GMU.
- (7) Provide the corrected GPS data file and MET file to FAATC for final processing.
- (8) FAATC will send Altimetry System Error (ASE) number to the CMA and the operator.