Handbook for AFI Regional Monitoring Agency (ARMA) Supporting Implementation and Continued Safe Use of the Reduced Vertical Separation Minimum

(February 2004)

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EXCLUSION OF LIABILITY

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PART 1

1. INTRODUCTION

1.1 Background

1.1.1 The concept of a regional monitoring agency (RMA) came out of the work done by the forerunner to the Separation and Airspace Safety Panel (SASP) known as the Review of the General Concept of Separation Panel (RGCSP) when it recognized that there was a requirement for monitoring of aircraft height-keeping performance as part of any reduced vertical separation minimum (RVSM) implementation program. In establishing this requirement, the RGCSP acknowledged that the RMA would take responsibility for ensuring that appropriate monitoring was carried out in order to provide sufficient data for completion of a risk assessment.

1.1.2 As the RGCSP developed technical material to guide RVSM introduction on a global and regional basis, it recognized that the role of the RMA was not limited solely to monitoring aircraft height-keeping performance. The RGCSP eventually conceived an RMA as an organization established by an authorized body to provide safety oversight services in connection with the implementation and continued safe use of RVSM within a designated airspace.

1.1.3 As each successive region has implemented RVSM, it has benefited from the experiences of previous implementations. In general terms, the implementation processes have followed the ICAO guidance set out in *Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between Fl 290 and Fl 410 Inclusive* (International Civil Aviation Organization, Doc 9574 (Second Edition – 2002)) but inevitably, local differences in the generic processes have emerged. As the move towards global implementation has continued, these differences have led to confusion within the RMAs and also within the operator community. It was decided, therefore, that this confusion should not be allowed to grow and the SASP adopted a work program to remedy the situation. This handbook is the outcome of that work.

1.2 Purpose of the Handbook

1.2.1 The purpose of this handbook is to provide a set of working principles common to all RMAs. It is not intended to provide exhaustive guidance on how to operate an RMA. Information on what is required of an RMA is to be found in Doc 9574 along with what is required from the RMA during each phase of the introduction of RVSM and thereafter.

1.3 General Description of RMA Functions

1.3.1 As noted, an RMA supports the implementation and continued safe use of RVSM within a designated airspace. In the context of RVSM, "safe" has a quantitative meaning: satisfaction of the agreed safety goal, or target level of safety (TLS). Section 2.1 of Doc 9574 describes the safety objectives associated with RVSM implementation and use. The TLS attributable to aircraft height-keeping performance, or the technical TLS, is defined in paragraph 2.1.4 of Doc 9574 as 2.5×10^{-9} fatal accidents per aircraft flight hour. In paragraph 2.1.6, the safety goal for risk due to all causes in connection with RVSM is left to regional agreement, with several examples of precedent indicating that the value used in practice should be consistent with 5×10^{-9} fatal accidents per aircraft flight hour.

1.3.2 Paragraphs 6.4.4 and 6.4.5 of Doc 9574 (Second Edition) provide a detailed list of RMA duties and responsibilities. These are shown in Appendix A. For purposes of overview, these can be summarized in five primary RMA functions:

1) Establish and maintain a database of RVSM approvals

2) Monitor aircraft height-keeping performance and the occurrence of large height deviations, and report results appropriately

3) Conduct safety and readiness assessments and report results appropriately

4) Monitor operator compliance with State approval requirements after RVSM implementation

5) Initiate necessary remedial actions if RVSM requirements are not met

1.3.3 The intent of this handbook is to standardize the activities of RMAs in executing these functions and the associated detailed duties and responsibilities of Doc 9574. A list of flight information regions and the associated cognizant RMA is contained in Appendix A.

1.4 Experience With the Role of the RMA in RVSM Implementation and Use

1.4.1 The initial RVSM implementation was in the majority of international airspace within the North Atlantic (NAT) Region in March 1997. As agreed at the Limited NAT Regional Air Navigation Meeting of October 1992, the NAT Central Monitoring Agency (CMA), a service provided by the United Kingdom's National Air Traffic Services Limited, filled the role of RMA for this implementation. EUROCONTROL carried out the functions of an RMA in connection with successful introduction of RVSM into the airspace of 41 European and adjacent States in January 2002. The Asia Pacific Approvals Registry and Monitoring Organization (APARMO), a service provided by the U.S. Federal Aviation Administration's Technical Center, was the RMA in support of RVSM introduction into all Pacific flight information regions in February 2000. The APARMO also supported RVSM implementation within most of the international airspace over the Western Pacific and South China Sea in February 2002.

1.4.2 The individual experiences of each of these RMAs in supporting the implementation and continued safe use of RVSM within the various portions of worldwide airspace within their scope of influence, as well their combined experiences in inter-RMA cooperation and data sharing, have provided the basis for development of this handbook. These RMAs have achieved a considerable level of standardization in communication links, data formats, analysis approaches and other factors necessary for the conduct of the RMA functions. These commonly agreed elements are provided within this handbook as a means of standardizing RMA practices.

1.5 Standards for Establishment and Operation of an RMA

1.5.1 Recognizing the safety oversight responsibilities necessary to support the implementation and continued safe use of RVSM, the following standards apply to any organization intending to fill the role of an RMA:

a) The organization must receive authority to act as an RMA as the result of a decision by a State, a group of States or a regional planning group, or by regional agreement;

b) The organization acting as an RMA should have personnel with the technical skills and experience to, carry out the following main functions:

i) establish and maintain a database of State RVSM approvals,

ii) monitor height-keeping performance,

iii) conduct safety and readiness assessments,

iv) monitor operator compliance with State approval requirements after RVSM implementation, and

v) initiate necessary remedial actions if RVSM requirements are not met

1.5.2 It is the responsibility of the organization authorizing establishment of an RMA to ensure that these standards are met. An example of a process satisfying this requirement would be for the organization intending to be an RMA in support of an RVSM implementation to participate in an apprentice or leader-follower program under the guidance of the NAT CMA or EUROCONTROL or the APARMO or a combination of these existing RMAs or by some other means approved by ICAO. The apprentice or leader-follower program would be approximately one year in length and include both formal and on-the-job type training.

LIST OF ABBREVIATIONS AND ACRONYMS

AAD	Assigned altitude deviation
ACC	Area Control Centre
APARMO	Asia Pacific Approvals Registry and Monitoring Agency
ASE	Altimetry system error
ATC	Air traffic control
ATS	Air traffic services
CARSAMMA	Caribbean/South American Regional Monitoring Agency
CFL	Cleared flight level
CMA	Central Monitoring Agency
CRM	Collision risk model
FL	Flight level
FTE	Flight Technical Error
GAT	General Air Traffic
GMS	GPS-based Monitoring System
GMU	GPS-based Monitoring Unit
GPS	Global Positioning System
HF	High frequency
HMU	Height Monitoring Unit
JAA	Joint Aviation Authorities
MAAR	Monitoring Agency for the Asia Region
MASPS	Minimum Aircraft System Performance Specification
MECMA	Middle East Central Monitoring Agency
MNPS	Minimum Navigation Performance Specification
NAARMO	North Atlantic Approvals Registry and Monitoring Agency
NAT	North Atlantic

NAT SPG	North Atlantic Systems Planning Group
NOTAM	Notice to airmen
OAT	Operational air traffic
RGCSP	Review of the General Concept of Separation Panel
RMA	Regional Monitoring Agency
RNAV	Area Navigation
RPG	Regional planning group
RVSM	Reduced vertical separation minimum of 300 m (1 000 ft) between FL 290 and FL 410 inclusive
SATMA	South Atlantic Monitoring Agency
SD	Standard deviation
SSR	Secondary surveillance radar
TCAS	Traffic Alert and Collision Avoidance System
TLS	Target level of safety
TVE	Total vertical error
VSM	Vertical separation minimum

LIST OF DEFINITIONS

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

Aberrant aircraft.

Those aircraft that exhibit measured height-keeping performance that is significantly different from the core height keeping performance measured for the whole population of aircraft operating in RVSM airspace.

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 that could influence the accuracy of height keeping performance.

Airworthiness Approval.

The process of assuring the State authority that aircraft meet the RVSM MASPS. Typically, this would involve an operator meeting the requirements of the aircraft manufacturer service bulletin for that aircraft and having the State authority verify the successful completion of this work.

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.

Altimetry System Error stability.

Altimetry system error for an individual aircraft is considered to be stable if the statistical distribution of altimetry system error is within agreed limits over an agreed period of time.

Altitude-keeping device.

Any equipment which is designed to automatically control the aircraft to a referenced pressure altitude.

Assigned Altitude Deviation (AAD).

The difference between the transponder Mode C altitude and the assigned altitude/flight level.

Automatic altitude-keeping device.

Any equipment which is designed to automatically control the aircraft to a referenced pressure altitude.

Collision risk.

The expected number of mid-air aircraft accidents in a prescribed volume of airspace for a specific number of flight hours due to loss of planned separation.

Note: . - One collision is considered to produce two accidents.

Flight Technical Error (FTE).

Difference between the altitude indicated by the altimeter display being used to control the aircraft and the assigned altitude/flight level.

Height-keeping capability.

Aircraft height-keeping performance which can be expected under nominal environmental operating conditions with proper aircraft operating practices and maintenance.

Height-keeping performance.

The observed performance of an aircraft with respect to adherence to cleared flight level.

Non-compliant aircraft.

An aircraft configured to comply with the requirements of the RVSM MASPS which, through height monitoring, is found to have a total vertical error (TVE) or an assigned altitude deviation (AAD) of 300 ft in magnitude or greater or an altimetry system error (ASE) of 245 ft in magnitude or more.

NOTAM.

A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

Occupancy.

A parameter of the collision risk model which is twice the count of aircraft proximate pairs in a single dimension divided by the total number of aircraft flying the candidate paths in the same time interval.

Operational Approval.

The process of assuring the State authority that an operator meets all the requirements for operating aircraft in airspace where RVSM has been implemented.

Operational Error.

Any vertical deviation of an aircraft from the correct flight level as a result of incorrect action by ATC or the aircraft crew.

Overall risk.

The risk of collision due to all causes, which includes the technical risk (see definition) and all risk due to operational errors and in-flight emergencies

Passing frequency.

The frequency of events in which the centers of mass of two aircraft are at least as close together as the metallic length of a typical aircraft when traveling in the opposite or same direction on the same route at adjacent flight levels and at the planned vertical separation.

RVSM Approval.

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

Target level of safety (TLS).

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

Technical risk.

The risk of collision associated with aircraft height-keeping performance.

Total vertical error (TVE).

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

Track.

The projection on the earth's surface of the path of an aircraft, the direction of which path at any point is usually expressed in degrees from North (True, Magnetic, or Grid).

Vertical separation.

The spacing provided between aircraft in the vertical plane to avoid collision.

Vertical separation minimum (VSM).

VSM is documented in the *Procedures for Air Navigation Services - Air Traffic* Management (PANS ATM, Doc 4444) as being a nominal 1 000 ft below FL 290 and 2 000 ft above FL 290 except where, on the basis of regional agreement, a value of less than 2 000 ft but not less than 1 000 ft is prescribed for use by aircraft operating above FL 290 within designated portions of the airspace.

PART 2

2. WORKING PRINCIPLES COMMON TO ALL REGIONAL MONITORING AGENCIES

2.0 As stated, the intent of this handbook is to introduce a common set of working principles for RMAs. These principles have been agreed as the result of the combined experience of the NAT CMA, EUROCONTROL and the APARMO. The principles are presented within this chapter in the context of the five main RMA functions listed in Section 1.3. The handbook provides a description of the overall activities associated with each function. In providing for the conduct of each function, it also provides agreed data formats, required communication linkages and appropriate references to ICAO documents and regional materials.

2.1 Establishment and Maintenance of an RVSM Approvals Database

2.1.1 The experience gained through the introduction of RVSM has shown that the concept of an RMA is essential to help to ensure safety in the region. It has a significant role to play in all aspects of the monitoring process. One of its functions is to establish a database of aircraft approved by their respective State authorities for operations at RVSM levels in the region for which the RMA has responsibility. This information is of vital importance if the height-keeping performance data collected by the height monitoring systems is to be effectively utilized in the risk assessment.

2.1.2 Although a global database approvals may seem highly desirable, RVSM is prescribed by the ICAO guidance material as a regional activity.

2.1.3 Aviation is a global industry and many aircraft operating in a region where RVSM has not previously been implemented may, nevertheless, be approved for RVSM operations and will have their approvals registered with another RMA. While it is currently an ICAO requirement for regions to establish an RVSM approvals database, it is envisaged that there is considerable scope for database sharing. In this regard, while a region introducing RVSM will need its own RMA to act as a focal point for the collection and collation of RVSM approvals for aircraft operating solely in that region, it may not need to maintain a complete database of all aircraft in the world that are RVSM approved. It will, however, be required to establish links with other RMAs in order to determine the RVSM status of aircraft it has monitored, or intends to monitor, so that an assessment of the technical height-keeping risk can be made.

2.1.4 To avoid duplication by States in registering approvals with RMAs, the concept of a cognizant RMA for the processing of approval data has been established. Under the cognizant RMA concept, all States are associated with a particular RMA for the processing of RVSM approvals. Appendix B provides a listing of States and the respective cognizant RMA for RVSM approvals. RMAs may contact any State to address safety matters without regard to the cognizant RMA for approvals.

2.1.5 It is important to note that, in general, the aircraft operating in airspace where RVSM introduction is planned can be categorized into two classes. Some aircraft operate solely within the airspace targeted for RVSM introduction and others operate both within that airspace and other portions of airspace. It is the responsibility of the RMA supporting introduction of RVSM to gather State approvals for the former category of aircraft from authorities issuing those approvals. To do so requires that the RMA establish a communication link with each such authority and provide a precise description of the approvals information required. Appendix C provides the pertinent forms, with a brief description of their use, that an RMA should supply to a State authority to obtain information on aircraft RVSM approval status.

2.1.6 Where possible, the RMA should collect State approvals information for the latter category of aircraft – those operating outside the targeted RVSM airspace – from other RMAs. This collection will be facilitated if each RMA maintains, in electronic form, a database of State RVSM approvals containing a minimum informational content for each approval

2.1.7 Appendix D contains the minimum database content and format, which should be maintained by an RMA. Appendix D also contains a description of the data to be shared by RMAs and the procedures for sharing.

2.2 Monitoring and Reporting Aircraft Height-Keeping Performance and the Occurrence of Large Height Deviations

2.2.1 An RMA must be prepared to collect the information necessary to assess operator compliance with the RVSM MASPS. In addition, it must institute procedures for the collection of information descriptive of large deviations from cleared flight level and of operational errors caused by non-compliance with ATC instructions or loop errors within the ATC system.

2.2.2 Experience has shown that monitoring of aircraft technical height-keeping performance is a challenging task requiring specialized systems. Experience has also shown that organizing and overseeing the collection of large height deviation information necessitates special procedures.

2.2.3 These two topics will be treated separately in this section. Data collection forms, database formats for storage of information and sharing with other RMAs, and reporting requirements and formats will be presented for each topic.

Monitoring Aircraft Height-Keeping Performance

2.2.4 Monitoring of aircraft height-keeping performance is a demanding enterprise, particularly as regards estimation of aircraft altimetry system error (ASE). Discussion of height-keeping performance monitoring first considers the technical requirements for a monitoring system and then examines the application of monitoring before and after RVSM implementation in an airspace. Furthermore, guidance on monitoring requirements for RVSM approved aircraft is provided along with suggested formats for storing monitoring data to more easily facilitate data exchange with other RMAs.

<u>Establishment of a technical height monitoring function</u>

2.2.5 The principal objectives of an RVSM monitoring program as established by ICAO in Doc 9574 are to:

i) provide guidance on the efficacy of the RVSM MASPS and on the effectiveness of altimetry system modifications;

ii) provide confidence that the TLS will be met under RVSM and will continue to be met thereafter; and

iii) provide evidence of ASE stability.

2.2.6 In order to achieve these objectives, a technical height monitoring function has to be established. Previously, regions have used either ground–based Height Monitoring Units (HMU) or air portable GPS Monitoring Units (GMUs). Whatever system(s) a region decides to use, the quality and reliability on the monitoring infrastructure and its output data must be ensured through correct specification of the systems and thorough verification of performance.

2.2.7 It is particularly important for RMAs to verify that height-monitoring data from whatever sources it uses can be combined for the purposes of the data analysis. For example this is especially important in any work to establish ASE stability, as the different measurement errors in individual systems could distort the results and indicate ASE instability when none exists - or vice-versa.

2.2.8 As a means to ensure both adequate accuracy in estimating Total Vertical Error (TVE) and transferability of monitoring results, an RMA must establish that any TVE estimation system which it administers has a mean measurement error of roughly 0 ft and a standard deviation of measurement error not in excess of 50 ft. Estimates of measurement errors associated with the HMU and GPS-based Monitoring System (GMS), which employs the GMU, indicate that each system satisfies these requirements, under the current operational conditions.

2.2.9 RMAs should work with RPGs to ensure that sufficient monitoring infrastructure is available to meet requirements. The monitoring infrastructure may consist of specialized systems and a support contractor or monitoring service provider. An RMA may establish suitable monitoring infrastructure through an arrangement with an existing RMA or through the development of new systems. New systems, in addition to meeting the requirements above, should be evaluated against existing systems. Support contractors may be selected on the basis of having contributed to the monitoring infrastructure of another region or be subject to a comparative analysis with an established system. RMAs may engage suitable regional organizations, such as the International Air Transport Association, to select a support contractor.

2.2.10 For further information on the merits and requirements of HMU and GMU monitoring systems, refer to Appendix N.

2.2.11 Previous RVSM implementation programs may provide a rich source of monitoring data for regions that have a limited monitoring capability. This should be borne in mind when establishing a technical height-monitoring program for both pre- and post-implementation monitoring purposes. To help regions decide on the degree of monitoring that is required, ICAO has established guidelines as outlined below.

Pre-implementation technical height monitoring requirements for a given region or portion thereof

2.2.12 The three objectives stated in Doc 9574, and noted in the previous section, for aircraft height-keeping performance monitoring are applicable to both the pre- and post-implementation phases. However, in general, evidence of ASE stability would not normally be expected to be a product of the pre-implementation phase monitoring as this is a long-term consideration.

2.2.13 The pre-implementation or verification phase of an RVSM program requires that a high proportion of the anticipated RVSM aircraft population meets the requirements of the RVSM MASPS.

2.2.14 In regard to interpreting the results of technical height monitoring during the pre-implementation phase of an RVSM program, the following should be taken into account:

i) It must be demonstrated that the technical TLS of 2.5 x 10^{-9} fatal accidents per flight hour has been met.

ii) Aircraft operator/type combinations to meet a pre-determined level, e.g. 2 airframes or 60 percent.

iii) Aircraft type-groups must demonstrate performance such that the absolute value of the group mean ASE is not in excess of 80ft and that the absolute value of the mean ASE + 3 standard deviations (SD) about the mean is not in excess of 245ft. No individual measurement should exceed a value of 245ft in magnitude, plus monitoring system measurement error.

iv) No individual measurement of ASE for each aircraft approved on a non-group basis for RVSM operations may exceed 160ft in magnitude, excluding monitoring system measurement error.

Note 1: Data from other regions may be used to meet the above objectives but the age of the data used will be dependent on on-going work on ASE stability.

Note 2: Subject to a satisfactory collision risk assessment and other operational considerations, performance verification could be terminated provided that 90 percent of the flights in the region, or part thereof, would be made by operators that have met the pre-determined minimum monitoring requirements.

2.2.15 Guidance regarding conduct of a safety assessment leading to an estimate of risk for comparison with the TLS referenced in i). above, will be provided in a later section of this document.

2.2.16 In regard to ii). above, Appendix E provides the agreed minimum monitoring requirements applicable to operator/aircraft-type combinations. Appendix E also contains the applied monitoring groups for aircraft certified or approved under group approval requirements. These monitoring groups represent the aircraft types and series that may be combined to satisfy the minimum monitoring requirements also contained in Appendix E. Adjustments to applied monitoring groups will be based on the analysis of monitoring data and coordinated among the RMAs. Appendix M contains guidance for RMAs in reducing minimum monitoring requirements.

2.2.17 It is especially important that an RMA act if its height-keeping performance monitoring system detects an individual aircraft ASE in excess of the 245 ft limit, after accounting for measurement error, noted in iii). above. Similarly, action should be taken for observations of TVE, after accounting for measurement error, or Assigned Altitude Deviation (AAD) of 300 ft or more. This action should consist of notifying the aircraft operator as well as the State authority granting the aircraft's RVSM approval. Appendix F contains a sample of such a letter.

2.2.18 A system needs to be established whereby the RPG or RMA sponsor is provided with timely notification of the actions taken on its behalf, as the result of an action initiated under 2.2.17

2.2.19 In order to facilitate the exchange of aircraft height-keeping performance monitoring data between RMAs, an RMA should maintain the minimum information identified in Appendix G for each observation of aircraft height-keeping performance obtained from the airspace within which it exercises its functions.

Post-implementation technical height monitoring requirements for a given region or portion thereof

2.2.20 The RPG will determine the reporting requirements for the RMA. These requirements would normally include the demonstration on an annual basis, that the technical TLS of 2.5 x 10^{-9} fatal accidents per flight hour continues to be met within the airspace for which the RMA has responsibility.

2.2.21 Aircraft type-groups must demonstrate performance such that the absolute value of the group mean ASE is not in excess of 80ft and that the absolute value of mean ASE + 3SD is not in excess of 245ft. No individual measurement should exceed a value of 245ft plus monitoring system measurement error.

2.2.22 No individual measurement of ASE for each aircraft approved on a non-group basis for RVSM operations, may exceed 160ft in magnitude, excluding monitoring system measurement error.

2.2.23 Operator/type combinations not previously monitored prior to implementation should be targeted for monitoring.

2.2.24 Aircraft operator/type combinations should continue to be monitored at the frequency prescribed by the RMA

Note 1 *Data from other regions may be used to meet the above objectives.*

Note 2 *The age of the data used will be dependent on on-going work on ASE stability*

Note 3 *The specific requirements for post-implementation monitoring, in addition to those listed above, are dependent on the stability of ASE. These requirements, including the frequency and time period required, are being developed by the SASP.*

Reporting of aircraft height-keeping performance statistics

2.2.25 Where an RMA is employing a height-keeping performance monitoring system producing substantial estimates of aircraft ASE, tabulations of ASE by aircraft groups, as identified in Appendix E, should be kept. The magnitude of mean ASE and magnitude of mean ASE + 3SD of ASE should be compared, respectively, to the limits of 80ft and 245ft, noted above, for each group annually and reported to the body authorizing RMA establishment.

2.2.26 When either of these limits is exceeded for an aircraft group, an RMA should have a process in place to examine the findings, e.g. through consultation with airworthiness and operations specialists. Groups consisting of specialists in these fields should be established for the RVSM airspace within which the RMA supports safety oversight.

2.2.27 Should these examinations indicate a potential systematic problem in group performance, an RMA, or other appropriate body, should initiate action to influence an improvement in performance. It is the RMA's task to bring performance issues having an impact on safety to the attention of State Authorities, aircraft manufacturers and Regional Planning Groups. Where applicable, the RMA should propose remedial measures. Such action should take the form of direct contact both with the State authority which issued airworthiness approval for the aircraft group in question and also with the aircraft manufacturer. It is important that an RMA keep in mind that it does not have the regulatory authority to require that improvements to performance be made. Only the State which approved the RVSM airworthiness documents for the aircraft group has such authority. These documents – in the form of an approved service bulletin, supplementary type certificate or similar State-approved material – provide directions to an operator regarding the steps necessary to bring an aircraft type into compliance with RVSM requirements. If there is a flaw in the ASE performance of an aircraft type, the ultimate goal of the RMA is to influence appropriate corrections to these documents. An RMA's actions to achieve this goal should be the following:

a) assemble all ASE monitoring data for the aircraft type from the airspace within which the RMA provides safety oversight in accordance with the approach shown in Appendix H;

b) assemble the measurement-error characteristics of the monitoring system or systems used to produce the results in (a);

c) as deemed relevant by the RMA, assemble all summary monitoring data – consisting of mean ASE, ASE SD, minimum ASE, maximum ASE, any flights found to be non-compliant with ASE requirements – from other Regions or airspace where the aircraft type has been monitored; and

d) by means of an official RMA letter, as illustrated in Appendix H,, inform the State authority, which approved the airworthiness documents for the aircraft group, and the manufacturer of the observation of allegedly inadequate ASE performance, citing:

   i) the requirement that an aircraft group's absolute value of mean ASE be less than or equal to 80 ft and that a group's absolute value of mean ASE plus 3 ASE SD's be less than 245 ft;

   ii) the data described in (a) and (b) and , as necessary, (c), which will be provided on request;

   iii) the need for compliance with these requirements in order to support safe RVSM operations within the airspace where the RMA conducts its safety oversight activities; and

   iv) a request to be informed of consequent State, manufacturer action to remedy the cause or causes of the observed performance, including any changes to the State airworthiness approval documents.

Monitoring the Occurrence of Large Height Deviations

2.2.28 Experience has shown that large height deviations – errors of 300 ft or more in magnitude – have had significant influence on the outcome of safety assessments before and after implementation of RVSM in a portion of airspace. Accordingly, a principal duty of an RMA is to ensure the existence of a program to report and assess the importance of such occurrences.

2.2.29 The causes of such errors have been found to be:

a) an error in the altimetry or altitude-keeping system of an aircraft,

b) turbulence and other weather-related phenomena,

c) an emergency descent by an aircraft without the crew following established contingency procedures,

d) response to airborne collision avoidance system (ACAS) advisories,

e) an error in following a correctly issued ATC clearance, resulting in flight at an incorrect flight level,

f) an error in issuing an ATC clearance, resulting in flight at an incorrect flight level, and

g) errors in coordination of the transfer of control responsibility for an aircraft between adjacent ATC units, resulting in flight at an incorrect flight level.

2.2.30 The aircraft height-keeping performance monitoring program administered by an RMA addresses the first of these causes. Section 2.2.17 provides direction to an RMA for action in the event that this program uncovers the occurrence of a large height deviation.

2.2.31 Within the airspace for which it is responsible, an RMA will need to establish the means to detect and report the occurrence of large height deviations due to the remaining causes. While an RMA will be the recipient and archivist for reports of large height deviations, it is important to note that an RMA alone cannot be expected to conduct all activities associated with a comprehensive program to detect and report large height deviations. Rather, an RMA should enlist the support of the ICAO regional planning group, the relevant ICAO regional office, the RVSM implementation task force, or any other entity that can assist in the establishment of such a program.

2.2.32 Experience has shown that the primary sources for reports of large height deviations are the ATC units providing air traffic control services in the airspace where RVSM is or will be applied. The surveillance information available to these units – in the form of voice or automatic dependent surveillance (ADS) reports and, where available, secondary surveillance radar Mode C returns – provides the basis for identifying large height deviations. A program for identifying large height deviations should be established, and ATC units should report such events monthly. It is the responsibility of an RMA to collect this information. These reports should contain, as a minimum, the following information:

a) Reporting unit

b) Location of deviation, either as latitude/longitude or ATC fix

c) Date and time of large height deviation

d) Sub-portion of airspace, such as established route system, if applicable

e) Flight identification and aircraft type

f) Assigned flight level

g) Final reported flight level or altitude and basis for establishment (pilot report or Mode C)

h) Duration at incorrect level or altitude

i) Cause of deviation

j) Any other traffic in potential conflict during deviation

k) Crew comments when notified of deviation

l) Remarks from ATC unit making report

A suggested form for these monthly reports is shown in Appendix I.

2.2.33 Other sources for reports of large height deviations should also be explored. An RMA is advised to determine if operators within the airspace for which it is responsible will share pertinent summary information from internal safety oversight databases. In addition, an RMA should enquire about access to State databases of safety incident reports which may be pertinent to the RVSM airspace. An RMA should also examine voluntary reporting safety databases, such as the Aviation Safety Reporting System administered by the U.S. National Aeronautics and Space Administration, as possible sources of large height deviation incidents in the airspace for which it is responsible.

2.3 Conducting Safety and Readiness Assessments and Reporting Results before RVSM Implementation

2.3.1 A safety assessment consists of estimating the risk of collision associated with the RVSM and comparing this risk to the agreed RVSM safety goal, the TLS. An RMA will need to acquire an in-depth knowledge of the use of the airspace within which RVSM will be implemented. This requirement will continue after implementation as the RMA carries out its duties. Experience has shown that such knowledge can be gained through acquisition of charts and other material describing the airspace, and through periodic collection of samples of traffic movements within the airspace. Currently, there is no standard Collision Risk Model (CRM) that is applicable to all airspace. Each Region has to adapt existing CRMs to take account of regional variations.

2.3.2 A readiness assessment is an examination of the approval status of operators and aircraft using airspace where RVSM is planned in order to evaluate whether a sufficiently high proportion of operations will be conducted by approved operators and aircraft when RVSM is introduced.

2.3.3 An RMA is responsible for conducting both safety and readiness assessments prior to RVSM implementation. The responsibility for conducting safety assessments continues after the 1000-ft vertical separation standard is introduced.

Safety Assessment

2.3.4 A principal duty of an RMA is to conduct a safety assessment prior to RVSM implementation. It is strongly recommended that an RMA conduct a series of safety assessments prior to RVSM implementation. These should start at least one year prior to the planned implementation date, in order to provide the organization overseeing RVSM introduction with early indications of any problems which must be remedied before RVSM may be implemented.

2.3.5 The RPG will state the safety reporting requirements for the RMA..

Establishing the Competence Necessary to Conduct a Safety Assessment

2.3.6 Conducting a safety assessment is a complex task requiring specialized skills which are not practiced widely. As a result, an RMA will need to pay special attention to ensuring that it has the necessary competence to complete this task prior to and after RVSM implementation.

2.3.7 Ideally, an RMA will have the internal competence to conduct a safety assessment. However, recognizing that personnel with the required skills may not be available internally, an RMA may find it necessary to augment its staff, either through arrangements with another RMA or with an organization possessing the necessary competence.

2.3.8 If it is necessary to use an external organization to conduct a safety assessment, an RMA must nevertheless have the internal competence to judge that such an assessment is done properly. This competence should be acquired through an arrangement with an RMA which has conducted safety assessments.

Preparations for Conduct of a Safety Assessment

2.3.9 In preparing to support an RVSM implementation, an RMA will need to take into account that a safety assessment must reflect the factors which influence collision risk within the airspace where RVSM will be applied. Thus, an RMA will need to establish the means for collecting and organizing pertinent data and other information descriptive of these airspace factors. As will be noted below, some data sources from other airspace where RVSM has been implemented may assist an RMA in conducting a safety assessment. However, an RMA may not use the overall safety assessment results from another portion of worldwide airspace as the sole justification for concluding that the TLS will be met in the airspace where the RMA has safety assessment responsibility.

<u>Assembling a sample of traffic movements from the airspace</u>

2.3.10 Samples of traffic movements should be collected for the entire airspace where RVSM will be implemented. As a result, ATC providers within the airspace may need to cooperate in the collection of samples. In this the case, an RMA will need to coordinate collection of traffic movement samples through the organization overseeing RVSM implementation.

2.3.11 The first sample of traffic movements should take place as soon as is practicable after the decision is made to implement RVSM within a particular airspace and the operational details of that application have been agreed. Examples of such details are whether an operator must have a State RVSM approval in order to plan a flight within the RVSM airspace, addition of routes where RVSM approval is required, any changes to direction-of-flight on existing routes and the like. “Operational concept” is one term used to describe the aggregate of these details.

2.3.12 An RMA should plan to collect at least two samples of traffic movement data prior to RVSM implementation, with the timing of the first as noted in the previous paragraph. The timing of the second sample should be as close to the planned time of implementation as is practicable in light of the time required to collect, process and analyze the sample, and to extract information necessary to support final safety and readiness assessments.

2.3.13 In planning the time and duration of a traffic sample, an RMA should take into account the importance of capturing any periods of heavy traffic flow which might result from seasonal or other factors. The duration of any traffic sample should be at least 30 days, with a longer sample period left to the judgment of an RMA.

2.3.14 The following information should be collected for each flight in the sample:

a) date of flight

b) flight identification or aircraft call sign, in standard ICAO format

c) aircraft type conducting the flight, as listed in the applicable edition of ICAO Doc 8643, Aircraft Type Designators

d) aircraft registration mark, if available

e) origin aerodrome, as listed in the applicable edition of ICAO Doc 7910, Location Indicators

f) destination aerodrome, as listed in the applicable edition of ICAO Doc 7910, Location Indicators

g) entry fix or latitude/longitude into RVSM airspace

h) time at entry fix

i) flight level at entry fix

j) exit fix or latitude/longitude leaving RVSM airspace

k) time at exit fix

l) flight level at exit fix

m) as many additional fix/time/flight-level combinations as the RMA judges are necessary to capture the traffic movement characteristics of the airspace

2.3.15 Where possible, in coordinating collection of the sample, an RMA should specify that information be provided in electronic form, for example, in a spreadsheet. Appendix J contains a sample specification for collection of traffic movement data in electronic form, where the entries in the first column may be used as column headings on a spreadsheet template.

2.3.16 Acceptable sources for the information required in a traffic movement sample are one or more of the following: special ATC observations, ATC automation systems, automated air traffic management systems and SSR reports.

Review of operational concept

2.3.17 Experience has shown that the operational concept adopted by bodies overseeing RVSM implementations can affect substantially the collision risk in airspace with a 1000-ft vertical separation standard. An example of this is a decision to apply the Table of Cruising Levels in Appendix 3 of Annex 2 to the Convention on International Civil Aviation, Rules of the Air, while using routes in a unidirectional manner. The consequence of this decision is to provide an effective 2000-ft vertical separation standard between aircraft at adjacent usable flight levels on a route.

2.3.18 In light of such possibilities, an RMA should review carefully the operational concept agreed by the body overseeing implementation of the RVSM with a view to identifying any features of planned airspace use which may influence risk. An RMA should inform the oversight body of any aspects of the operational concept which it considers important in this respect.

Agreed Process for Determining Whether the TLS is Met as the Result of a Safety Assessment

2.3.19 “Technical risk” is the term used to describe the risk of collision associated with aircraft height-keeping performance. Some of the factors which contribute to technical risk are:

a) errors in aircraft altimetry and altitude-keeping systems

b) aircraft equipment failures resulting in unmitigated deviation from cleared flight level, including those where not following the required procedures further increase the risk.

c) response to false ACAS resolution advisories

Intuitively, such factors affect risk more if the planned vertical separation between a pair of aircraft is 1000ft than if a 2000ft standard is in use.

2.3.20 The term “operational error” is used to describe any vertical deviation of an aircraft from the correct flight level as a result of incorrect action by ATC or the aircraft crew. Examples of such actions are:

a) a flight crew misunderstanding a proper ATC clearance and operating at a flight level other than that issued in the clearance

b) ATC issuing a clearance which places an aircraft at a flight level where provision has not necessarily been made for adequate separation from other aircraft

c) a coordination failure between ATC units in transfer of control responsibility for an aircraft resulting in either no notification of the transfer or in transfer at an unexpected flight level

d) inappropriate response to a valid ACAS resolution advisory

e) wrong pressure setting on the altimeters e.g. QNH remains set

2.3.21 On initial consideration, the relation between the required vertical separation and the risk due to operational errors may be less clear than is the case with technical risk. However, as will be pointed out during subsequent discussion of risk modeling, introduction of RVSM does increase the risk associated with such errors if all other factors remain unchanged when transitioning from a 2000-ft to a 1000-ft vertical separation standard value. When carrying out the risk assessment, care should be taken to avoid including a single event in both the assessment of technical and operational risk.

2.3.22 The overall RVSM safety goal value which must be satisfied is a TLS value of 5×10^{-9} fatal accidents per flight hour due to all causes of risk associated with RVSM. In order to declare that this safety goal has been met, an RMA must determine that the following two conditions hold simultaneously:

1) the technical risk does not exceed a value of 2.5×10^{-9} fatal accidents per flight hour, and

2) the sum of the technical risk and the risk resulting from operational errors does not exceed a value of 5×10^{-9} fatal accidents per flight hour

2.3.23 The requirement that these two conditions hold simultaneously means that there is a firm bound on technical risk – 2.5×10^{-9} fatal accidents per flight hour – but no similar established maximum tolerable value for risk due to operational errors. Thus, it is possible that application of risk modeling can result in an estimate of technical risk less than 2.5×10^{-9} fatal accidents per flight hour and an estimate of operational risk in excess of this value, with the sum of the two still satisfying the TLS. On the other hand, if the estimate of technical risk exceeds 2.5×10^{-9} fatal accidents per flight hour, it is not possible to satisfy the TLS – even if the sum of the estimated technical and operational risks does not exceed 5×10^{-9} fatal accidents per flight hour

Collision Risk Model Used in Safety Assessment

2.3.24 This guidance will not present derivation or details of the collision risk model to be used in conducting a safety assessment. An RMA should acquire that background through review of the following publications:

a) *Report of the Sixth Meeting Review of the General Concept of Separation Panel, RGCSP/6*, Montreal, 28 November - 15 December 1988, Volumes 1 and 2, ICAO Doc 9536

b) "Risk Assessment and System Monitoring[1], August 1996"which is obtainable from the, ICAO European and North Atlantic Office.

[1] This material was contained in NAT Doc 002 which is no longer in print, however, the Supplement is still available.

c) "EUR RVSM Mathematical Supplement," Document RVSM 830, European Organization for the Safety of Air Navigation (Eurocontrol), August 2001

d) "Guidance Material on the Implementation of a 300m (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Asia Pacific Region," Appendix C, ICAO Asia and Pacific Office, Bangkok, October 2000

2.3.25 The Report of RGCSP/6 contains the derivation of the basic mathematical vertical collision risk model, as well as a description of the choice of a value for the portion of the TLS applied to technical risk.

2.3.26 The North Atlantic and Eurocontrol documents, contain the detailed safety assessment processes and procedures applied in two Regions in preparation for RVSM implementation. Appendix K presents an overview of the mathematical models used in the North Atlantic safety assessment process.

Readiness Assessment

2.3.27 A readiness assessment is a comparison of the actual and predicted proportion of operations conducted by State-approved operators and aircraft in an airspace prior to RVSM implementation to a threshold proportion established by the body overseeing the implementation. Such an assessment is most meaningful when the oversight body has agreed that the RVSM will be applied on an exclusionary basis, that is, that all flights planned to be operated in the airspace must be conducted by an operator and aircraft with State RVSM approval.

2.3.28 An RMA will require two sources of information to conduct a readiness assessment: a sample of traffic movements from the relevant airspace and the database of State RVSM approvals.

2.3.29 An RMA should organize the traffic movement sample by the number of operations for each operator/aircraft-type pair and then by the number of operations for each registration mark within each such pair, if registration marks are available in the sample. The approval status of each pair should then be checked using the database of State approvals and the total number of operations conducted by approved pairs summed. The ratio of this sum to the total number of operations in the sample provides the proportion of operations conducted by State-approved operators and aircraft and can be compared to the readiness threshold.

2.3.30 An RMA should report the readiness status of operators and aircraft periodically during the period of preparation for RVSM implementation. It has been found useful to make such a report each meeting of the organization overseeing RVSM implementation.

2.3.31 Experience indicates that it is important to take into account the future approval intent of operators when conducting a readiness assessment. An RMA should, therefore, attempt to establish the approval intentions of operators and include this information as a companion report to the readiness assessment.

2.4 Safety Reporting and Monitoring Operator Compliance with State Approval Requirements after RVSM Implementation

2.4.1 The responsibilities of an RMA continue after RVSM implementation. The overall intent of RMA activities after implementation is to support continued safe use of the RVSM.

2.4.2 After RVSM implementation, the RPG should consider that the RMA conduct an annual safety assessment as a means to determine whether the TLS continues to be met.

2.4.3 One important post-implementation activity is carrying out periodic checks of the approval status of operators and aircraft using airspace where RVSM is applied. This activity is especially vital if RVSM is applied on an exclusionary basis, that is, if State RVSM approval is a prerequisite for use of the airspace. This activity is termed as monitoring operator compliance with State approval requirements.

2.4.4 An RMA will require two sources of information to monitor operator compliance with State approval requirements: a listing of the operators, aircraft and registration marks conducting operations in the airspace; and the database of State RVSM approvals.

2.4.5 Ideally, this compliance monitoring should be done for the entire airspace on a daily basis. Difficulties in accessing traffic movement information may make such daily monitoring impossible. As a minimum, an RMA should conduct compliance monitoring of the complete airspace for at least a 30-day period annually.

2.4.6 When conducting compliance monitoring, the filed RVSM approval status shown on the flight plan of each traffic movement should be compared to the database of State RVSM approvals. When a flight plan shows an RVSM approval not confirmed in the database, the appropriate State authority should be contacted for clarification of the discrepancy. An RMA should use a letter similar in form to that shown in Appendix L for the official notification.

2.4.7 An RMA should keep in mind that the State authority has the responsibility to take any action should an operator be found to have filed a false declaration of State RVSM approval.

2.5 Remedial Actions

2.5.1 Remedial actions are those measures taken to remove causes of systematic problems associated with factors affecting safe use of the RVSM. Remedial actions may be necessary to remove the causes of problems such as the following:

a) failure of an aircraft group to comply with group ASE requirements

b) aircraft operating practices resulting in large height deviations

c) operational errors

2.5.2 An RMA should review monitoring results periodically in order to determine if there is evidence of any recurring problems.

2.5.3 An RMA should design its program of height-keeping performance monitoring program to provide ongoing summary information of ASE performance by aircraft group so that adverse trends can be identified quickly. When non-compliant ASE performance is confirmed for an aircraft group, an RMA should follow the procedures described in this guidance.

2.5.4 As a minimum, an RMA should conduct an annual review of reports of large height deviations with a view toward uncovering systematic problems. Should such a problem be discovered, an RMA should report its findings to the organization overseeing RVSM implementation if RVSM has not yet been introduced, or to the organization that authorized the establishment of the RMA. An RMA should include in its report the details of large height deviation suggesting the existence of a systematic problem.

LIST OF APPENDICES

APPENDIX A -

Regional Monitoring Agency Duties and Responsibilities

Source: *Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between Fl 290 and Fl 410 Inclusive,*
International Civil Aviation Organization - Doc 9574 (Second Edition – 2002)

The duties and responsibilities of a regional monitoring agency are:

1) establish a database of aircraft approved by the respective State authorities for operations at RVSM levels in that region.

2) to receive reports of those height deviations of non-compliant aircraft which are of a magnitude equal to or greater than the following criteria:

    a) TVE – 90 m (300 ft)
    b) ASE – 75 m (245 ft)
    c) AAD – 90 m (300 ft)

3) to take the necessary action with the relevant State and operator to:

    a) determine the likely cause of the height deviation; and
    b) verify the approval status of the relevant operator

4) to recommend, wherever possible, remedial action

5) to analyse data to detect height deviation trends and, hence, to take action as in the previous item

6) to undertake such data collections as required by the RPG to:

    a) investigate height-keeping performance of the aircraft in the core of the distribution;

    b) establish or add to a database on the height-keeping performance of:

        - the aircraft population
        - aircraft types or categories; and
        - individual airframes

7) to monitor the level of risk as a consequence of operational errors and in-flight contingencies as follows:

    a) establish a mechanism for collation and analysis of all reports of height deviations of 90 m (300 ft) or more resulting from the above errors/actions;

    b) determine, wherever possible, the root cause of each deviation together with its size and duration;

    c) calculate the frequency of occurrence;

    d) assess the overall risk (technical combined with operational and in-flight contingencies) in the system against the overall safety objectives (see 2.1 of Doc 9574); and

    e) initiate remedial action as required

8) to initiate checks of the "approval status" of aircraft operating in the relevant RVSM airspace (see 4.3.3 to 4.3.6 of Doc 9574), identify non-approved operators and aircraft using RVSM airspace and notify the appropriate State of Registry/State of the Operator accordingly;

9) to circulate regular reports on all height-keeping deviations, together with such graphs and tables necessary to relate the estimated system risk to the TLS, employing the criteria detailed in 6.2.8 of Doc 9574, for which formats are suggested in Appendix A to Doc 9574; and

10) to submit annual reports to the regional planning group.

Flight Information Regions and Responsible Regional Monitoring Agency

Responsible RMA	FIR
APARMO	Anchorage Oceanic
APARMO	Auckland Oceanic
APARMO	Brisbane Oceanic
APARMO	Honiara
APARMO	Inchon
APARMO	Melbourne Oceanic
APARMO	Nadi
APARMO	Naha
APARMO	Nauru
APARMO	Oakland Oceanic
APARMO	Port Moresby
APARMO	Tahiti
APARMO	Tokyo
ARMA	Accra
ARMA	Addis Ababa
ARMA	Antananarivo
ARMA	Beirra
ARMA	Brazzaville
ARMA	Bujumbura
ARMA	Cape Town
ARMA	Dakar
ARMA	Dakar Oceanic
ARMA	Dar Es Salam
ARMA	Entebbe
ARMA	Gaberone
ARMA	Harare
ARMA	Johannesburg
ARMA	Kano
ARMA	Kigalai
ARMA	Kingshasa
ARMA	Khartoum
ARMA	Lilongwe
ARMA	Luanda
ARMA	Lusaka
ARMA	Mauritius
ARMA	Mogadisho
ARMA	N'Djamena
ARMA	Nairobi
ARMA	Roberts
ARMA	Sal Oceanic
ARMA	Seychelles
ARMA	Windhoek
ARMA	Santo Domingo

Responsible RMA	FIR
APARMO	Anchorage Oceanic
APARMO	Auckland Oceanic
APARMO	Brisbane Oceanic
APARMO	Honiara
APARMO	Inchon
APARMO	Melbourne Oceanic
APARMO	Nadi
APARMO	Naha
APARMO	Nauru
APARMO	Oakland Oceanic
APARMO	Port Moresby
APARMO	Tahiti
APARMO	Tokyo
CARSAMMA	Antofagasta
CARSAMMA	Asuncion
CARSAMMA	Barranquilla
CARSAMMA	Belem
CARSAMMA	Bogota
CARSAMMA	Brasilia
CARSAMMA	Central American
CARSAMMA	Comodoro Rivadavia
CARSAMMA	Cordoba
CARSAMMA	Curacao
CARSAMMA	Curitiba
CARSAMMA	Easter Island
CARSAMMA	Ezeiza
CARSAMMA	Georgetown
CARSAMMA	Guayaquil
CARSAMMA	Havana
CARSAMMA	Kingston
CARSAMMA	La Paz
CARSAMMA	Lima
CARSAMMA	Maiquetia
CARSAMMA	Mendoza
CARSAMMA	Montevideo
CARSAMMA	Panama
CARSAMMA	Paramaribo
CARSAMMA	Piarco
CARSAMMA	Port Au Prince
CARSAMMA	Porto Velho
CARSAMMA	Puerto Montt
CARSAMMA	Punta Arenas
CARSAMMA	Recife
CARSAMMA	Resistencia
CARSAMMA	Rouchambeau
CARSAMMA	Santiago
CARSAMMA	Santo Domingo
CMA	Bodo Oceanic

Responsible RMA	FIR
CMA	Gander
CMA	New York Oceanic
CMA	Reyjkvik
CMA	Santa Maria
CMA	Shanwick
EUROCONTROL	Ankara
EUROCONTROL	Athinai
EUROCONTROL	Barcelona
EUROCONTROL	Beograd
EUROCONTROL	Berlin
EUROCONTROL	Bodø
EUROCONTROL	Bratislava
EUROCONTROL	Bremen
EUROCONTROL	Brest
EUROCONTROL	Brindisi
EUROCONTROL	Bruxelles
EUROCONTROL	Bucuresti
EUROCONTROL	Budapest
EUROCONTROL	Chisinau
EUROCONTROL	Düsseldorf
EUROCONTROL	France
EUROCONTROL	Frankfurt
EUROCONTROL	Hannover
EUROCONTROL	Istanbul
EUROCONTROL	Kaliningrad
EUROCONTROL	Kharkiv
EUROCONTROL	København
EUROCONTROL	Kyiv
EUROCONTROL	Lisboa
EUROCONTROL	Ljubljana
EUROCONTROL	London
EUROCONTROL	L'viv
EUROCONTROL	Madrid
EUROCONTROL	Malmö
EUROCONTROL	Malta
EUROCONTROL	Milano
EUROCONTROL	Minsk
EUROCONTROL	München
EUROCONTROL	Nicosia
EUROCONTROL	Odesa
EUROCONTROL	Oslo
EUROCONTROL	Praha
EUROCONTROL	Rhein
EUROCONTROL	Riga
EUROCONTROL	Roma
EUROCONTROL	Rovaniemi
EUROCONTROL	Sarajevo
EUROCONTROL	Scottish
EUROCONTROL	Shannon

Responsible RMA	FIR
EUROCONTROL	Simferopol
EUROCONTROL	Skopje
EUROCONTROL	Sofia
EUROCONTROL	Stavanger
EUROCONTROL	Stockholm
EUROCONTROL	Sundsvall
EUROCONTROL	Switzerland
EUROCONTROL	Tallinn
EUROCONTROL	Tampere
EUROCONTROL	Tirana
EUROCONTROL	Trondheim
EUROCONTROL	Varna
EUROCONTROL	Vilnius
EUROCONTROL	Warszawa
EUROCONTROL	Wien
EUROCONTROL	Zagreb.
EUROCONTROL	Amsterdam
MAAR	Bangkok
MAAR	Calcutta
MAAR	Chennai
MAAR	Colombo
MAAR	Delhi
MAAR	Dhaka
MAAR	Hanoi
MAAR	Ho Chi Minh
MAAR	Hong Kong
MAAR	Jakarta
MAAR	Karachi
MAAR	Kathmandu
MAAR	Kota Kinabalu
MAAR	Kuala Lumpur
MAAR	Lahore
MAAR	Male
MAAR	Manila
MAAR	Mumbai
MAAR	Phnom Penh
MAAR	Sanya AOR
MAAR	Singapore
MAAR	Taibei
MAAR	Ujung Pandang
MAAR	Vientiane
MAAR	Yangon
MECMA	Amman
MECMA	Bahrain
MECMA	Beriut
MECMA	Cario
MECMA	Jeddah
MECMA	Muscat
MECMA	Tehran

Responsible RMA	FIR
MECMA	UAE
NAARMO	Albuquerque
NAARMO	Anchorage
NAARMO	Anchorage Arctic
NAARMO	Anchorage Continental
NAARMO	Atlanta
NAARMO	Boston
NAARMO	Chicago
NAARMO	Cleveland
NAARMO	Denver
NAARMO	Edmonton
NAARMO	Fort Worth
NAARMO	Gander Domestic
NAARMO	Houston
NAARMO	Houston Oceanic
NAARMO	Indianapolis
NAARMO	Jacksonville
NAARMO	Kansas City
NAARMO	Los Angeles
NAARMO	Mazatlan
NAARMO	Mazatlan Oceanic
NAARMO	Memphis
NAARMO	Merida
NAARMO	Mexico
NAARMO	Miami
NAARMO	Miami Oceanic
NAARMO	Minneapolis
NAARMO	Monkton
NAARMO	Monterrey
NAARMO	Montreal
NAARMO	New York
NAARMO	Oakland
NAARMO	Salt Lake
NAARMO	San Juan
NAARMO	Seattle
NAARMO	Toronto
NAARMO	Vancouver
NAARMO	Washington
NAARMO	Winnipeg
SATMA	Recife
SATMA	Canarias South

APENDIX B -

States and Cognizant RMA for the reporting of RVSM approvals

The following table provides a listing of States and the respective cognizant RMA for the reporting of RVSM approvals, for distribution by the cognizant RMA.

ICAO Contracting State	Cognizant RMA for RVSM Approvals
Afghanistan	MAAR
Albania	EUROCONTROL
Algeria	EUROCONTROL
Andorra	EUROCONTROL
Angola	ARMA
Antigua and Barbuda	CARSAMMA
Argentina	CARSAMMA
Armenia	EUROCONTROL
Australia	APARMO
Austria	EUROCONTROL
Azerbaijan	EUROCONTROL
Bahamas	CARSAMMA
Bahrain	MECMA
Bangladesh	MAAR
Barbados	CARSAMMA
Belarus	EUROCONTROL
Belgium	EUROCONTROL
Belize	CARSAMMA
Benin	ARMA
Bhutan	MAAR
Bolivia	CARSAMMA
Bosnia and Herzegovina	EUROCONTROL
Botswana	ARMA
Brazil	CARSAMMA
Brunei Darussalam	APARMO
Bulgaria	EUROCONTROL
Burkina Faso	ARMA
Burundi	ARMA
Cambodia	MAAR
Cameroon	ARMA
Canada	NAARMO
Cape Verde	ARMA
Central African Republic	EUROCONTROL
Chad	ARAMA
Chile	CARSAMMA
China	MAAR
Colombia	CARSAMMA
Comoros	ARMA
Congo	ARMA
Cook Islands	APARMO
Costa Rica	CARSAMMA
Côte d'Ivoire	ARMA
Croatia	EUROCONTROL

ICAO Contracting State	Cognizant RMA for RVSM Approvals
Cuba	CARSAMMA
Cyprus	EUROCONTROL
Czech Republic	EUROCONTROL
Democratic People's Republic of Korea	MAAR
Democratic Republic of the Congo	ARMA
Denmark	EUROCONTROL
Djibouti	ARMA
Dominican Republic	CARSAMMA
Ecuador	CARSAMMA
Egypt	MECMA
El Salvador	CARSAMMA
Equatorial Guinea	ARMA
Eritrea	ARMA
Estonia	EUROCONTROL
Ethiopia	ARMA
Fiji	APARMO
Finland	EUROCONTROL
France	EUROCONTROL
Gabon	ARMA
Gambia	ARMA
Georgia	EUROCONTROL
Germany	EUROCONTROL
Ghana	ARMA
Greece	EUROCONTROL
Grenada	CARSAMMA
Guatemala	CARSAMMA
Guinea	ARMA
Guinea-Bissau	ARMA
Guyana	CARSAMMA
Haiti	CARSAMMA
Honduras	CARSAMMA
Hungary	EUROCONTROL
Iceland	CMA
India	MAAR
Indonesia	MAAR
Iran (Islamic Republic of)	MECMA
Iraq	MECMA
Ireland	CMA
Israel	EUROCONTROL
Italy	EUROCONTROL
Jamaica	CARSAMMA
Japan	APARMO
Jordan	MECMA
Kazakhstan	EUROCONTROL
Kenya	ARMA
Kiribati	APARMO
Kuwait	MECMA
Kyrgyzstan	EUROCONTROL
Lao People's Democratic Republic	MAAR
Latvia	EUROCONTROL
Lebanon	MECMA

ICAO Contracting State	Cognizant RMA for RVSM Approvals
Lesotho	ARMA
Liberia	EUROCONTROL
Libyan Arab Jamahiriya	MECMA
Lithuania	EUROCONTROL
Luxembourg	EUROCONTROL
Madagascar	ARMA
Malawi	ARMA
Malaysia	MAAR
Maldives	MAAR
Mali	ARMA
Malta	EUROCONTROL
Marshall Islands	APARMO
Mauritania	ARMA
Mauritius	ARMA
Mexico	NAARMO
Micronesia (Federated States of)	APARMO
Monaco	EUROCONTROL
Mongolia	MAAR
Morocco	EUROCONTROL
Mozambique	ARMA
Myanmar	MAAR
Namibia	ARMA
Nauru	APARMO
Nepal	MAAR
Netherlands, the Kingdom of	EUROCONTROL
New Zealand	APARMO
Nicaragua	CARSAMMA
Niger	ARMA
Nigeria	ARMA
Norway	CMA
Oman	MECMA
Pakistan	MECMA
Palau	APARMO
Panama	CARSAMMA
Papua New Guinea	APARMO
Paraguay	CARSAMMA
Peru	CARSAMMA
Philippines	APARMO
Poland	EUROCONTROL
Portugal	CMA
Qatar	MECMA
Republic of Korea	APARMO
Republic of Moldova	EUROCONTROL
Romania	EUROCONTROL
Russian Federation	EUROCONTROL
Rwanda	ARMA
Saint Kitts and Nevis	CARSAMMA
Saint Lucia	CARSAMMA
Saint Vincent and the Grenadines	CARSAMMA
Samoa	APARMO
San Marino	EUROCONTROL

ICAO Contracting State	Cognizant RMA for RVSM Approvals
Sao Tome and Principe	ARMA
Saudi Arabia	MECMA
Senegal	ARMA
Seychelles	ARMA
Sierra Leone	ARMA
Singapore	MAAR
Slovakia	EUROCONTROL
Slovenia	EUROCONTROL
Solomon Islands	APARMO
Somalia	ARMA
South Africa	ARMA
Spain	SATMA
Sri Lanka	MAAR
Sudan	ARMA
Suriname	CARSAMMA
Swaziland	ARMA
Sweden	CMA
Switzerland	EUROCONTROL
Syrian Arab Republic	MECMA
Tajikistan	EUROCONTROL
Thailand	MAAR
The former Yugoslav Republic of Macedonia	EUROCONTROL
Togo	ARMA
Tonga	APARMO
Trinidad and Tobago	CARSAMMA
Tunisia	EUROCONTROL
Turkey	EUROCONTROL
Turkmenistan	EUROCONTROL
Uganda	ARMA
Ukraine	EUROCONTROL
United Arab Emirates	MECMA
United Kingdom	CMA
United Republic of Tanzania	ARMA
United States	NAARMO
Uruguay	CARSAMMA
Uzbekistan	EUROCONTROL
Vanuatu	APARMO
Venezuela	CARSAMMA
Viet Nam	MAAR
Yemen	MECMA
Serbia and Montenegro	EUROCONTROL
Zambia	ARMA
Zimbabwe	ARMA

APPENDIX C -

RMA forms for use in obtaining record of RVSM approvals from a State authority

NOTES TO AID COMPLETION OF RMA FORMS F1, F2, AND F3

1. Please read these notes before attempting to complete forms RMA F1, F2, and F3.

2. It is important for the RMAs to have an accurate record of a point of contact for any queries that might arise from on-going height monitoring. Recipients are therefore requested to include a completed RMA F1 with their first reply to the RMA. Thereafter, there is no further requirement unless there has been a change to the information requested on the form.

3. If recipients are unable to pass the information requested in the RMA F2 to the RMA through the Internet, by direct electronic transfer, or by data placed on a 3.5" floppy disk, a hard copy RMA F2 must be completed for each aircraft granted RVSM approval. The numbers below refer to the superscript numbers on the blank RMA F2.

   (1) Enter the single letter ICAO identifier as contained in ICAO Doc 7910. In the case of their being more than one identifier designated for the State, use the letter identifier that appears first.
   (2) Enter the operator's 3 letter ICAO identifier as contained in ICAO Doc 8585. For International General Aviation, enter "IGA". For military aircraft, enter "MIL". If none, place an X in this field and write the name of the operator/owner in the Remarks row.
   (3) Enter the ICAO designator as contained in ICAO Doc 8643, e.g., for Airbus A320-211, enter A320; for Boeing B747-438 enter B744.
   (4) Enter series of aircraft type or manufacturer's customer designation, e.g., for Airbus A320-211, enter 211; for Boeing B747-438, enter 400 or 438.
   (5) Enter ICAO allocated Aircraft Mode S address code.
   (6) Enter yes or no.
   (7) Example: For October 26, 1998 write 10/26/98.
   (8) Use a separate sheet of paper if insufficient space available.

4. The above numbers refer to those superscript numbers used in RMA F3 - "Withdrawal of Approval to Operate in RMA RVSM Airspace." ***RMA F3 must be completed and forwarded to the RMA immediately when the state of registry has cause to withdraw the approval of an operator/aircraft for operations with RMA RVSM Airspace.***

RMA F1
POINT OF CONTACT DETAILS/CHANGE OF POINT OF CONTACT DETAILS FOR MATTERS RELATING TO RMA APPROVALS

This form should be completed and returned to the address below on the first reply to the RMA or when there is a change to any of the details requested on the form (PLEASE USE BLOCK CAPITALS).

STATE OF REGISTRY:

STATE OF REGISTRY (ICAO 2 LETTER IDENTIFIER):
Enter the 2-letter ICAO identifier as contained in ICAO Doc 7910. In the event that there is more than one identifier for the same State, the one that appears first in the list should be used.

ADDRESS:

CONTACT PERSON:

Full Name:

Title: Surname: Initials:

Post/Position:

Telephone #: Fax #: e

E-mail:

Initial Reply*/Change of Details* (**Delete as appropriate)*

When complete, please return to the following address:

RMA Address

Telephone:; Fax:
E-Mail:

RMA F2
RECORD OF APPROVAL TO OPERATE IN RMA RVSM AIRSPACE

1. When a State of Registry approves or amends the approval of an operator/aircraft for RVSM operations, details of that approval must be recorded and sent to the appropriate RMA without delay.

2. *Before providing the information as requested below, reference should be made to the accompanying notes* **(PLEASE USE BLOCK CAPITALS)**.

State of Registry[1]:

Name of Operator[2]:

State of Operator[1]:

Aircraft Type[3]:

Aircraft Series[4]:

Manufacturers Serial No:

Registration No:

Mode S Address Code[5]:

Airworthiness Approval[6]:

Date Issued[7]:

RVSM Approval[6]:

Date Issued[7]:

Date of Expiry[7] (If Applicable):

Method of Compliance (Service Bulletin, STC etc):

Remarks[8]:

When complete, please return to the following address.
RMA Address

Telephone:; Fax:
E-Mail:

RMA F3
WITHDRAWAL OF APPROVAL TO OPERATE IN RMA RVSM AIRSPACE

1. When a State of Registry has cause to withdraw the approval of an operator/aircraft for operations within the RMA airspace, details as requested below, must be submitted to the RMA by the most appropriate method.

2. *Before providing the information as requested below, reference below, reference should be made to the accompanying notes* **(PLEASE USE BLOCK CAPITALS)**.

State of Registry[1]:

Name of Operator[2]:

State of Operator[1]:

Aircraft Type[3]:

Aircraft Series[4]:

Manufacturers Serial No:

Registration:

Aircraft Mode S Address Code[5]:

Date of Withdrawal of RVSM Approval[7]:

Reason for Withdrawal of RVSM Approval[8]:

Remarks:

When complete, please return to the following address.

RMA Address

Telephone:; Fax:
E-Mail:

APPENDIX D -

Minimal informational content for each State RVSM approval to be maintained in electronic form by an RMA

Aircraft RVSM Approvals Data

To properly maintain and track RVSM approval information some basic aircraft identification information is required (e.g., manufacturer, type, serial number, etc.) as well as details specific to an aircraft's RVSM approval status. Table 1 lists the minimum data fields to be collected by an RMA for an individual aircraft. Table 1a describes the approvals database record format.

Note: This appendix primarily details the different data elements to be stored by and/or exchange between RMAs. The details of data types, unit and format will be defined in document TBA

Table1. Aircraft RVSM Approvals Data

Field	Description
Registration Number	Aircraft's current registration number.
Mode S	Aircraft's current Mode S code 6 hexadecimal digits.
Serial Number	Aircraft Serial Number as given by manufacturer
ICAO type Designator	Aircraft Type as defined by ICAO document 8643
Series	Aircraft generic series as described by the aircraft manufacturer (e.g., 747-100, series = 100).
State of Registry	State to which the aircraft is currently registered as defined in ICAO document 7910
Reg. Date	Date registration was active for current operator.
Operator ICAO Code	ICAO code for the current Operator as defined in ICAO document 8585.
Operator Name	Name of the current Operator.
State of Operator	State of the current Operator as defined in ICAO document .7910
Civil or military indication *	Aircraft is civil or military
Airworthiness (MASPS) Approved	Yes or no indication of airworthiness approval
Date Airworthiness Approved	Date of Airworthiness Approval
RVSM Approved	Yes or no indication RVSM approval
Region for RVSM Approval	Name of region where the RVSM approval is applicable Note: Only required if RVSM Approval is issued for a specific region.
State Of RVSM Approval	State granting RVSM approval as defined in ICAO document 7910
Date RVSM Approved	Date of RVSM Approval
Date of RVSM Expiry	Date of Expiry for RVSM Approval
Method of Compliance (service bulletin or STC)	Reference number/name of compliance method used to make a/c MASPS compliant.
Remarks	Open comments
Date of Withdraw of Airworthiness (MASPS) Approval	Date of withdraw of the aircraft's Airworthiness approval (if applicable)
Date of Withdraw of full RVSM approval	Date of withdraw of the aircraft's RVSM approval (if applicable)
Info by Authority	Yes or no indication " Was the information

Field	Description
	provide to the RMA by a State Authority?”

* not necessarily a separate field. Can be a field on its own, or. It is indicated in the operator ICAO code as MIL when the military has an ICAO code designator.

Table 1a. Approvals Database Record Format

Field	Description	Type	Width	Valid Range
1	State of Registry	Alphabetic	2	AA-ZZ
2	Operator	Alphabetic	3	AAA-ZZZ
3	State of Operator	Alphabetic	2	AA-ZZ
4	Aircraft Type	Alphanumeric	4	e.g. MD11
5	Aircraft Mark / Series	Alphanumeric	6	
6	Manufacturer's Serial/Construction Number	Alphanumeric	12	
7	Aircraft Registration Number	Alphanumeric	10	
8	Aircraft Mode "S" Address (Hexadecimal)	Alphanumeric	6	
9	Airworthiness Approved	Alphabetic	1	"Y", "N"
10	Date Airworthiness Approval Issued (dd/mm/yyyy)	Date	8	e.g. 31/12/1999
11	RVSM Approved	Alphabetic	1	"Y", "N"
12	Date RVSM Approval Issued (dd/mm/yyyy)	Date	8	e.g. 31/12/1999
13	Date of Expiry of RVSM Approval (if any) (dd/mm/yyyy)	Date	8	e.g. 31/12/1999
14	National Remarks	Alphanumeric	60	ASCII text
15	Method of compliance	Alphanumeric	60	ASCII text

Aircraft Re-Registration/Operating Status Change Data

Aircraft frequently change registration information. Re-registration and change of operating status information is required to properly maintain an accurate list of the current population as well as to correctly identify height measurements. Table 2 lists the minimum data fields to be maintained by an RMA to manage aircraft re-registration/operating status change data.

Table2. Aircraft Re-Registration/Operating Status Change Data

Field	Description
Reason for change	Reason for change. Aircraft was re-registered, destroyed, parked, etc.
Previous Registration Number	Aircraft's previous registration number.
Previous Mode S	Aircraft's previous Mode S code.
Previous Operator Name	Previous name of operator of the aircraft.
Previous, Operator ICAO Code	ICAO code for previous aircraft operator.
Previous State of the Operator	ICAO code for the previous State of the operator
State of New Operator	ICAO code for the State of the current aircraft operator.
New Registration Number	Aircraft's current registration number.
New State of Registration	Aircraft's current State of Registry.
New Operator Name	Current name of operator of the aircraft.
New Operator ICAO Code	ICAO code for the current aircraft operator.
Aircraft ICAO Type designator	Aircraft Type as defined by ICAO document 8643
Aircraft Series	Aircraft generic series as described by the aircraft manufacturer (e.g., 747-100, series = 100).
Serial Number	Aircraft Serial Number as given by manufacturer
New Mode S	Aircraft's current Mode S code 6 hexadecimal digits.
Date change is effective	Date new registration/ change of status became effective.

Contact Data

An accurate and up to date list of contacts is essential for an RMA to do business. Table 3 lists the minimum content for organizational contacts and Table 4 lists the minimum content for individual points-of-contact.

Table3. Organizational Contact Data

Field	Description
Type	Type of contact (e.g., Operator, Airworthiness Authority, Manufacturer)
State	State in which the company is located.
State ICAO	ICAO code for the State in which the company is located.
Company/Authority	Name of the company/authority as used by ICAO (e.g., Bombardier)
Fax No	Fax number for the company.
Telephone Number	Telephone number for the company.
Address (1-4)	Address lines 1-4 filled as appropriate for the company.
Place	Place (city, etc.) in which the company is located.
Postal code	Postal code for the company.
Country	Country in which the company is located.
Remarks	Open comments
Modification Date	Last Modification Date.
Web Site	Company Web HTTP Location.
e-mail	Company e-mail address.
civ/mil	Civil or Military.

Table 4. Individual Point of Contact Data

Field	Description
Title Contact	Mr., Mrs., Ms., etc.
Surname Contact	Surname of point of contact.
Name Contact	Name of point of contact.
Position Contact	Work title of the point of contact.
Company/Authority	Name of the company/authority as used by ICAO (e.g., Bombardier)
Department	Department for the point of contact.
Address (1-4)	Address lines 1-4 filled as appropriate for the point of contact.
Place	Place (city, etc.) in which the point of contact is located.
Postal code	Postal code for the location of the point of contact.
Country	Country in which the point of contact is located.
State	State in which the point of contact is located.
E-mail	E-mail of the point of contact.
Telex	Telex number of the point of contact.
Fax No	Fax number of the point of contact.
Telephone no 1	First telephone number for the point of contact.
Telephone no 2	Second telephone number for the point of contact.

Data Exchange Between RMAs

The following sections describe how data is to be shared between RMAs as well as the minimum data set that should be passed from one RMA to another. This minimum sharing data set is a sub-set of the data defined in previous sections of Appendix D.

All RMAs receiving data have responsibility to help ensure data integrity. A receiving RMA must report back to the sending RMA any discrepancies or incorrect information found in the sent data. Also, for detailed questions about a height measurement, an RMA must refer Operator or Authority to the RMA responsible for taking the measurement.

Data Exchange Procedures

The standard mode of exchange shall be e-mail or FTP. Data shall be presented in Microsoft Excel or Access. Because of the size of the data files, any large height-monitoring-data requests shall be made by arrangement between RMAs. RMAs must realize when making a request, that the data is current only to the date of the created file.

Table5. RMA Data Exchange Procedures

Data Type	Data Subset	Frequency	When
RVSM Approvals	All	Monthly	First week in month
Aircraft Re-registration/status	New since last broadcast	Monthly	First week in month
Contact	All	Monthly	First week in month
Height Monitoring Data	As Specified (HMU, GMS or HMU and GMS) height-monitoring data from region that created the data	As Requested	
Monitoring Targets	All	As Required	Whenever changed
Non-Compliant Aircraft/Group	All	As Required.	As Occurs

In addition to regular data exchanges, one-off queries shall be given to an RMA on request. This includes requests for data in addition to the minimum exchanged data set such as additional height measurement fields or service bulletin information.

Exchange of Aircraft Approvals Data

An RMA shall only exchange RVSM Approvals data with another RMA when an aircraft is at minimum Airworthiness Approved. The following table defines the fields required for sending a record to another RMA.

Table6. Exchange of Aircraft Approvals Data

Field	Needed to Share
Registration Number	Mandatory
Mode S	Desirable
Serial Number	Mandatory
ICAO type Designator	Mandatory
Series	Mandatory
State of Registry	Mandatory
Registration Date	Desirable
Operator ICAO Code	Mandatory
Operator Name	Desirable
State of Operator	Mandatory
Civil or military indication (not a field on its own. It is indicated in the ICAO operator code as MIL except when the military has a code)	Desirable
Airworthiness (MASPS) Approved	Mandatory
Date Airworthiness Approved	Mandatory
RVSM Approved	Mandatory
State Of RVSM Approval	Mandatory
Date RVSM Approved	Mandatory
Date of RVSM Expiry	Mandatory
Method of Compliance (service bulletin or STC)	Desirable
Remarks	No
Date of Withdraw of Airworthiness (MASPS) Approval	Mandatory
Date of Withdraw of full RVSM approval	Mandatory
Info by Authority	Mandatory

** ????

Aircraft Re-Registration/Operating Status Change Data

An RMA shall share all re-registration information.

Table7. Exchange of Aircraft Re-Registration/Operating Status Change Data

Field	Need to Share
Reason for change (ie. re-registered, destroyed, parked)	Mandatory
Previous Registration Number	Mandatory
Previous Mode S	Desirable
Previous Operator Name	Desirable
Previous, Operator ICAO Code	Mandatory
Previous State of Operator	Mandatory
State of Operator	Mandatory
New registration number	Mandatory
New State of Registration	Mandatory
New Operator Name	Desirable
New Operator Code	Desirable
Aircraft ICAO Type designator	Mandatory
Aircraft Series	Mandatory
Serial Number	Mandatory
New Mode S	Mandatory
Date change is effective	Desirable

Exchange of Height measurement data

Height measurement data shall only be exchanged when the data can be positively linked to an aircraft that is MASPS/Airworthiness approved. In addition this data must be reliable as measured by the geometric reliability and the met quality data and quality control checks.

Table8. Exchange of Height measurement data

Field	Need to Share
Date of Measurement	Mandatory
Time of Measurement	Mandatory
Measurement Instrument*	Mandatory
A/C Mode S as taken by measurement system	Mandatory
A/C registration number	Mandatory
A/C serial Number.	Mandatory
Aircraft ICAO designator	Mandatory
Operator ICAO Code	Mandatory
Aircraft ICAO type Designator	Mandatory
Aircraft Series	Mandatory
Mean mode C altitude during Measurement	Mandatory
Assigned Altitude at Time of Measurement	Mandatory
Estimated TVE	Mandatory
Estimated AAD	Mandatory
Estimated ASE	Mandatory
Compliance Status **	Mandatory

** Only if common definition
* ????

Exchange of Contact Data

Only State Data, Manufacturer and Design Organizations

Table9. Exchange of Organizational Contact Data Fields

Field	Need to Share
Type	Mandatory
State	Mandatory
State ICAO	Desirable
Company/Authority	Mandatory
Fax No	Desirable
Telephone Number	Desirable
Address (1-4)	Desirable
Place	Desirable
Postal code	Desirable
Country	Desirable
e-mail	Desirable
civ/mil	Desirable

Table10. Exchange of Individual Point of Contact Data Fields

Field	Need to Share
Title Contact	Desirable
Surname Contact	Mandatory
Name Contact	Desirable
Position Contact	Desirable
Company/Authority	Mandatory
Department	Desirable
Address (1-4)	Desirable
Place	Desirable
Postal code	Desirable
Country	Desirable
State	Desirable
E-mail	Desirable
Fax No	Desirable
Telephone no 1	Desirable
Telephone no 2	Desirable

Monitoring Targets

All data that defines an RMAs monitoring targets shall be shared.

Confirmed Non-Compliant Information

As part of its monitoring assessments an RMA may identify a non-compliant aircraft or discover an aircraft group that is not meeting the ICAO performance requirements or the MASPS. This should be made available to other RMAs.

When identifying a non-compliant aircraft an RMA should include

- Notifying RMA
- Date Sent
- Field
- Registration Number
- Mode S
- Serial Number
- ICAO Type Designator
- State of Registry
- Registration Date
- Operator ICAO Code
- Operator Name
- State of Operator
- Date(s) of non-compliant measurement(s)
- Action Started (y/n)
- Date Aircraft Fixed

When identifying an aircraft group that is not meeting the MASPS an RMA should include

- Notifying RMA
- Aircraft Group
- Action Started (y/n)
- Specific monitoring data analysis information

Data specific to Height Monitoring and Risk Assessment
This data will not be shared between RMAs as it is specific to the airspace being assessed and in some cases confidential information. This includes Flight Plan Data, Operational Error Data, Occupancy Data, Aircraft type proportions, and Flight time information.

Fixed parameters -Reference Data Sources
Some of the data that are used internally to an RMA and form some of the standard for data formats are listed below.

- ICAO Doc. 7910 " Location Indicators"
- ICAO Document 8585 " Designators for Aircraft Operating Agencies, Aeronautical Authorities, and Services"
- ICAO Document 8643 " Aircraft Type Designators"
- IATA "Airline Coding Directory"

APPENDIX E -

MINIMUM MONITORING REQUIREMENTS

1. **Monitoring prior to the issue of RVSM approval is not a requirement**. However, operators should be prepared to submit monitoring plans to their State aviation organizations that demonstrate how they intend to meet the requirements specified in the table below. Monitoring will be carried out in accordance with this table, for pre-RVSM implementation after an aircraft has received airworthiness approval, and for post RVSM-implementation, after an aircraft operator has been approved for RVSM operations.

2. Any aircraft type not specified in the table below will most likely be subject to the monitoring requirements as indicated in Category 2. However, this and any other query in respect of monitoring requirements can be clarified by contacting the appropriate Regional Monitoring Agency (RMA).

MONITORING IS REQUIRED IN ACCORDANCE WITH THIS CHART

MONITORING PRIOR TO THE ISSUE OF RVSM APPROVAL IS **NOT** A REQUIREMENT

CATEGORY		**AIRCRAFT TYPE**	**MINIMUM OPERATOR MONITORING FOR EACH AIRCRAFT GROUP**
1	GROUP APPROVED: DATA INDICATES COMPLIANCE WITH THE RVSM MASPS	[A30B, A306], [A312 (GE) A313(GE)], [A312 (PW) A313(PW)], A318, [A319, A320, A321], [A332, A333], [A342, A343], A345, A346 B712, [B721, B722], B732, [B733, B734, B735], B737(Cargo), [B736, B737/BBJ, B738/BBJ, B739], [B741, B742, B743], B74S, B744 (5" Probe), B744 (10" Probe), B752, B753, [B762, B763], B764, B772, B773 CL60(600/601), CL60(604), C560, [CRJ1, CRJ2], CRJ7, DC10, F100, GLF4, GLF5, LJ60, MD10, MD11, MD80 (All series), MD90, T154	10% or Two airframes from each fleet* of an operator to be monitored as soon as possible but not later than 6 months after the issue of RVSM approval and thereafter as directed by the RMA * *Note. For the purposes of monitoring, aircraft within parenthesis [ ] may be considered as belonging to the same fleet. For example, an operator with six A332 and four A333 aircraft may monitor one A332 and one A333* ***or*** *two A332 aircraft* ***or*** *two A333 aircraft.*
2	GROUP APPROVED: INSUFFICIENT DATA ON APPROVED AIRCRAFT	Other group aircraft other than those listed above including: A124, ASTR, B703, B731, BE20,BE40, C500, C25A, C25B, C525, C550**, C56X, C650, C750, CRJ9, [DC86, DC87], DC93, DC95, [E135, E145], F2TH, [FA50 FA50EX], F70, [F900, F900EX], FA20, FA10, GLF2(II), GLF(IIB), GLF3, GALX,, GLEX, H25B(700), H25B(800), H25C, IL62, IL76, IL86, IL96, J328, L101, L29(2), L29(731), LJ31, [LJ35,LJ36], LJ45, LJ55, SBR1, T134, T204, P180, PRM1,YK42	60% of airframes from each fleet of an operator **or** individual monitoring, as soon as possible but not later than 6 months after the issue of RVSM approval and thereafter as directed by the RMA . ** Refer to aircraft group table for detail on C550 monitoring
3	Non-Group	Non-group approved aircraft	100% of aircraft shall be monitored as soon as possible but not later than 6 months after the issue of RVSM approval.

Note: The above table represents the minimum monitoring requirements; but RMAs may increase these requirements at their discretion.

Applied Monitoring Groups for Aircraft Certified under Group Approval Requirements

Monitoring Group	A/C ICAO	A/C Type	A/C Series
A124	A124	AN-124 RUSLAN	ALL SERIES
A300	A306 A30B	A300 A300	600, 600F, 600R, 620, 620R, 620RF B2-100, B2-200, B4-100, B4-100F, B4-120, B4-200, B4-200F, B4-220, C4-200
A310-GE	A310	A310	200, 200F,300, 300F
A310-PW	A310	A310	220, 220F,320
A318	A318	A318	ALL SERIES
A320	A319 A320 A321	A319 A320 A321	CJ , 110, 130 110, 210, 230 110, 130, 210, 230
A330	A332, A333	A330	200, 220, 240, 300, 320, 340
A340	A342, A343,	A340	210, 310
A345	A345	A340	540
A346	A346	A340	640
A3ST	A3ST	A300	600R ST BELUGA
AN72	AN72	AN-74, AN-72	ALL SERIES
ASTR	ASTR	1125 ASTRA	ALL SERIES
ASTR-SPX	ASTR	ASTR SPX	ALL SERIES
AVRO	RJ1H, RJ70, RJ85	AVRO	RJ70, RJ85, RJ100
B712	B712	B717	200
B727	B721 B722	B727	100, 100C, 100F,100QF, 200, 200F
B732	B732	B737	200, 200C
B737CL	B733 B734 B735	B737	300, 400, 500
B737NX	B736 B737 B738 B739	B737 B737 B737 B737	600 700, 700BBJ 800, BBJ2 900
B737C	B737	B737	700C
B747CL	B741 B742 B743	B747	100, 100B, 100F, 200B, 200C, 200F, 200SF, 300
B74S	B74S	B747	SR, SP
B744-5	B744	B747	400, 400D, 400F (With 5 inch Probes)
B744-10	B744	B747	400, 400D, 400F (With 10 inch

Monitoring Group	A/C ICAO	A/C Type	A/C Series
			Probes)
B752	B752	B757	200, 200PF
B753	B753	B757	300
B767	B762 B763	B767	200, 200EM, 200ER, 200ERM, 300, 300ER, 300ERF
B764	B764	B767	400ER
B772	B772	B777	200, 200ER, 300, 300ER
B773	B773	B777	300, 300ER
BE40	BE40	BEECHJET 400A	ALL SERIES
BE20	BE20	BEECH 200 -KINGAIR	ALL SERIES
C500	C500	500 CITATION, 500 CITATION I, 501 CITATION I SINGLE PILOT	ALL SERIES
C525	C525	525 CITATIONJET, 525 CITATIONJET I	ALL SERIES
C525-II	C25A	525A CITATIONJET II	ALL SERIES
C525 CJ3	C25B	CITATIONJET III	ALL SERIES
C550-552	C550	552 CITATION II	ALL SERIES
C550-B	C550	550 CITATION BRAVO	ALL SERIES
C550-II	C550	550 CITATION II, 551 CITATION II SINGLE PILOT	ALL SERIES
C550-SII	C550	S550 CITATION SUPER II	ALL SERIES
C560	C560	560 CITATION V, 560 CITATION V ULTRA, 560 CITATION V ULTRA ENCORE	ALL SERIES
C56X	C56X	560 CITATION EXCEL	ALL SERIES
C650	C650	650 CITATION III , 650 CITATION VI , 650 CITATION VII	ALL SERIES
C750	C750	750 CITATION X	ALL SERIES
CARJ	CRJ1, CRJ2	REGIONALJET	100, 200, 200ER, 200LR
CRJ-700	CRJ7	REGIONALJET	700
CRJ-900	CRJ9	REGIONALJET	900
CL600	CL60	CL-600 CL-601	CL-600-1A11 CL-600-2A12, CL-600-2B16
CL604	CL60	CL-604	CL-600-2B16
BD100	CL30	CHALLENGER 300	ALL SERIES
BD700	GL5T	GLOBAL 5000	ALL SERIES
CONC	CONC	CONCORDE	ALL SERIES
DC10	DC10	DC-10	10, 10F, 15, 30, 30F, 40, 40F
DC86-7	DC86, DC87	DC-8	62, 62F, 72, 72F

Monitoring Group	A/C ICAO	A/C Type	A/C Series
DC93	DC93	DC-9	30, 30F
DC95	DC95	DC-9	SERIES 51
E135-145	E135, E145	EMB-135, EMB-145	ALL SERIES
F100	F100	FOKKER 100	ALL SERIES
F2TH	F2TH	FALCON 2000	ALL SERIES
F70	F70	FOKKER 70	ALL SERIES
F900	F900	FALCON 900, FALCON 900EX	ALL SERIES
FA10	FA10	FALCON 10	ALL SERIES
FA20	FA20	FALCON 20 FALCON 200	ALL SERIES
FA50	FA50	FALCON 50, FALCON 50EX	ALL SERIES
GALX	GALX	1126 GALAXY	ALL SERIES
GLEX	GLEX	BD-700 GLOBAL EXPRESS	ALL SERIES
GLF2	GLF2	GULFSTREAM II (G-1159),	ALL SERIES
GLF2B	GLF2	GULFSTREAM IIB (G-1159B)	ALL SERIES
GLF3	GLF3	GULFSTREAM III (G-1159A)	ALL SERIES
GLF4	GLF4	GULFSTREAM IV (G-1159C)	ALL SERIES
GLF5	GLF5	GULFSTREAM V (G-1159D)	ALL SERIES
H25B-700	H25B	BAE 125 / HS125	700B
H25B-800	H25B	BAE 125 / HAWKER 800XP, BAE 125 / HAWKER 800, BAE 125 / HS125	ALL SERIES/A, B/800
H25C	H25C	BAE 125 / HAWKER 1000	A , B
IL86	IL86	IL-86	NO SERIES
IL96	IL96	IL-96	M , T, 300
J328	J328	328JET	ALL SERIES
L101	L101	L-1011 TRISTAR	1 (385-1), 40 (385-1), 50 (385-1), 100, 150 (385-1-14), 200, 250 (385-1-15), 500 (385-3)
L29B-2	L29B	L-1329 JETSTAR 2	ALL SERIES
L29B-731	L29B	L-1329 JETSTAR 731	ALL SERIES
LJ31	LJ31	LEARJET 31	NO SERIES, A
LJ35/6	LJ35 LJ36	LEARJET 35 LEARJET 36	NO SERIES, A
LJ40	LJ40	LEARJET 40	ALL SERIES
LJ45	LJ45	LEARJET 45	ALL SERIES
LJ55	LJ55	LEARJET 55	NO SERIES B, C
LJ60	LJ60	LEARJET 60	ALL SERIES

Monitoring Group	A/C ICAO	A/C Type	A/C Series
MD10	MD10	MD-10	ALL SERIES
MD11	MD11	MD-11	COMBI, ER, FREIGHTER, PASSENGER
MD80	MD81, MD82, MD83, MD87, MD88	MD-80	81, 82, 83, 87, 88
MD90	MD90	MD-90	30, 30ER
P180	P180	P-180 AVANTI	ALL SERIES
PRM1	PRM1	PREMIER 1	ALL SERIES
T134	T134	TU-134	A, B
T154	T154	TU-154	A , B, M, S
T204	T204, T224, T234	TU-204, TU-224, TU-234	100, 100C, 120RR, 200, C
YK42	YK42	YAK-42	ALL SERIES

Note this list is not considered exhaustive.

APPENDIX F -

Sample letter to an Operator of an aircraft observed to have exhibited an altimetry system error in excess of 245 ft in magnitude

Operator

HEIGHT KEEPING PERFORMANCE IN RVSM AIRSPACE

Dear Mr ,

On (*date)*, a 1000ft Reduced Vertical Separation Minimum (RVSM) was introduced in *X* Airspace. The introduction and continued operation of RVSM is conditional on the risk of collision as a consequence of the loss of vertical separation is less that the agreed Target Level of Safety (TLS) of 5×10^{-9} fatal accidents per flight hour.

Since 25th May 2000, as part of the process to verify that the TLS is being achieved, the height keeping performance of aircraft holding RVSM MASPS approval have and are being monitored in accordance with ICAO requirements.

On *date* a flight, aircraft registration *xyz,* Modes S Code *xyz*, which we believe to be operated by you and notified as being RVSM MASPS compliant by *operator*, was monitored by the *Monitoring unit* as having an Altimetry System Error (ASE) = *x*.

For a detailed explanation on the height keeping requirements you may wish to refer to JAA TGL 6.

This measurement indicates that the aircraft **may not be** compliant with the height keeping accuracy requirements for RVSM airspace. It is therefore requested that an immediate investigation be undertaken into this discrepancy and the necessary arrangements are made for a repeat measurement at the earliest opportunity following any rectification or inspection of the altimetry system.

The findings of your investigation should be summarised on the enclosed “Height keeping Investigation Form” and returned to RMA at the address given.

We would ask that you acknowledge receipt of this communication as soon as possible by fax or telephone to

RMA Contact details

Thank you for your continued co-operation.

Yours Faithfully,

CC:

State authority of aircraft registration/operation

HEIGHT KEEPING ERROR INVESTIGATION FORM

Part 1 – General Information

State of Registry	
Operator	
State of Operator	
Aircraft Type & Series	
Registration	
Serial Number	
Mode S Address	

Part 2 – Details of Height Keeping Error

A shaded box with bold figures indicates an excess of the JAA TGJ6 REV1 requirements (taking into account measurement error)

Date & Time of Measurement	Assigned Flight Level	Altimetry System Error (feet)	Assigned Altitude Deviation (feet)	Total Vertical Error (feet)

Provide details below of the fault found (if any) plus date and nature of the rectification work. Please also include a estimate of the number of flight the aircraft has performed in European airspace between the date of measurement and rectification

When complete, please return to

RMA Contact details

APPENDIX G -

Minimim information for each monitored aircraft to be maintained in electronic form by an RMA

AIRCRAFT HEIGHT-KEEPING PERFORMANCE MONITORING DATA RECORD FORMAT

FIELD	FIELD IDENTIFIER	FIELD DATA TYPE	WIDTH	RANGE
1	Validity Indicator	Alphabetic	1	"C": Compliant "A": Aberrant "N": Non-Compliant
2	Date of Measurement (dd/mm/yyyy)	Date	8	e.g. 01/01/1996
3	Time of Measurement (hh:mm:ss)	Time	8	e.g. 12:00:00
4	Measuring Instrument	Alphanumeric	4	e.g. "HYQX" "G123"
5	Aircraft Mode "A" Identity (octal)	Alphanumeric	4	
6	Aircraft Mode "S" Address (hexadecimal)	Alphanumeric	6	
7	Aircraft Registration Number	Alphanumeric	10	
8	Flight Call Sign	Alphanumeric	7	
9	Operator	Alphabetic	3	
10	Aircraft Type	Alphanumeric	4	
11	Aircraft Mark/Series	Alphanumeric	6	
12	Flight Origin	Alphabetic	4	
13	Flight Destination	Alphabetic	4	
14	Mean Mode "C" Altitude During Measurement[1]	Numeric	5	0-99999 This field may be Null for GMS
15	Assigned Altitude at Time of Measurement[1]	Numeric	5	0-99999
16	Mean Estimated Geometric Height of Aircraft	Numeric	5	0-99999
17	SD of Estimated Geometric Height of Aircraft	Numeric	5	0-99999
18	Mean Geometric Height of Assigned Altitude	Numeric	5	0-99999
19	Estimated TVE	Numeric	4	0-9999
20	Minimum Estimated TVE*	Numeric	4	0-9999
21	Maximum Estimated TVE*	Numeric	4	0-9999
22	SD of Estimated TVE*	Numeric	4	0-9999
23	Estimated AAD	Numeric	4	0-9999
24	Minimum Estimated AAD*	Numeric	4	0-9999
25	Maximum Estimated AAD*	Numeric	4	0-9999
26	SD of Estimated AAD*	Numeric	4	0-9999
27	Estimated ASE	Numeric	4	0-9999
28	Minimum Estimated ASE*	Numeric	4	0-9999
29	Maximum Estimated ASE*	Numeric	4	0-9999
30	SD of Estimated ASE*	Numeric	4	0-9999
31	Indicator for Reliability of Geometric Height Measurement	Numeric	3	HMU: 0.0-1.0 GMU: 0.0-9.9
32	Indicator of Reliability of Met Data	Numeric	1	0.1
33	Aircraft Serial/Construction Number	Alphanumeric	12	e.g. 550-0848

* only when more than one data point is available

APPENDIX H -

Altimetry System Error Data and Analysis to be provided to State and Manufacturer by an RMA

1.1.1 When an RMA judges that monitoring data from the airspace within which it supports safety oversight indicates that an aircraft group may not meet ASE requirements for mean magnitude and standard deviation (SD), the following monitoring results should be assembled:

(1) The mean magnitude of ASE and ASE SD of all monitored flights

(2) The following information for each monitored flight:

(i) the ASE estimate,

(ii) the date on which monitoring took place,

(iii) the registration mark of the aircraft conducting the flight

(iv) the mach number flown during monitoring (if available)

(v) the altimetry system – captain's or first officer's – observed by the monitoring system (if available)

(vi) the date on which RVSM airworthiness approval was granted for the monitored aircraft

(vii) the date on which the aircraft was first put into service by an operator (if available)

(viii) the monitoring system used to obtain the estimate, and

(ix) the location where the monitoring took place

SAMPLE LETTER

To State concerned

Dear X,

RE: *(aircraft type)* RVSM HEIGHT KEEPING PERFORMANCE.

As you are aware, *(organisation*), acting as the Regional Monitoring Agency (RMA) on behalf of ICAO, is required to perform height keeping performance assessment enabling the identification of performance issues and for ongoing safety assessments. Since the introduction of RVSM in EUR RVSM airspace, this role is performed in the context of <u>current</u> RVSM operations and the safety of these operations.

As a basis for the safety of RVSM operations, ICAO has set a requirement for aircraft groups, i.e. Mean ASE<80ft and Mean ASE plus 3 Standard Deviations<245 ft. From this requirement, RVSM certification requirements have been derived which are laid down in JAA TGL6, to ensure that this important safety requirement is not exceeded.

When monitored altimetry system performance indicates that an aircraft group is not meeting the above stated ICAO requirement, while the group is operating as RVSM approved in RVSM airspace, this may have safety implications and is as such not acceptable. Therefore, in this situation immediate action needs to be taken to ensure that the group complies with the group requirement. This may be achieved by (1) withdrawing the type RVSM approval, in order to reconsider the effectiveness of the type RVSM solution or by (2) removing the approval for those aircraft for which available performance data indicates that without these aircraft the group performance requirement is met.

After adjusting the data set regarding the latest approval status of *(aircraft type)* aircraft and the associated measurement history, the present group performance has been reassessed. The data as of the 23rd July 2002 shows that the group performance is exceeding the requirements set by ICAO. The current group performance has been determined to be:

	(aircraft type)
Mean ASE	ft
Mean + 3 STDEV	ft

As previously stated this performance may have safety implications. We therefore request that you take necessary action to ensure that the group performance of the RVSM approved *(aircraft type)* aircraft operating in RVSM airspace complies with the ICAO requirement with immediate effect, or that these aircraft no longer operate in RVSM airspace until group compliance with the ICAO requirement is met.

Please do not hesitate to inquire if we can help you in any way to support your activities to resolve this issue.

Your urgent response would be appreciated.

Yours sincerely

etc

Cc
Manufacturer

APPENDIX I -

Suggested Form for ATC Unit Monthly Report of Large Height Deviations

REGIONAL MONITORING AGENCY NAME

Report of Large Height Deviation

Report to the (Regional Monitoring Agency Name) of an height deviation of 300 ft or more, including those due to ACAS, turbulence and contingency events.
Name of ATC unit:____

Please complete Section I or II as appropriate

SECTION I:

There were no reports of large height deviations for the month of __________

SECTION II:

There was/were _____ report(s) of a height deviation of 300 ft or more between FL290 and FL410. Details of the height deviation are attached.

(Please use a separate form for each report of height deviation).

SECTION III:

When complete please forward the report(s) to:

Regional Monitoring Agency Name
Postal address
Telephone:
Fax:
E-Mail:

RMA F4

APPENDIX J -

Sample Content and Format for Collection of Sample of Traffic Movements

The following table lists the information required for each flight in a sample of traffic movements.

INFORMATION FOR EACH FLIGHT IN THE SAMPLE

The information requested for a flight in the sample is listed in the following table with an indication as to whether the information is necessary or is optional:

ITEM	EXAMPLE	NECESSARY OR OPTIONAL
Date (either month/day/year or day/month/year format)	5/01/00 or 01/05/00 for 1 May 2000	NECESSARY
Aircraft call sign	MAS704	NECESSARY
Aircraft Type	B734	NECESSARY
Origin Aerodrome	WMKK	NECESSARY
Destination Aerodrome	RPLL	NECESSARY
Entry Fix into RVSM Airspace	MESOK	NECESSARY
Time at Entry Fix	2:25 (or 0225)	NECESSARY
Flight Level at Entry Fix	330	NECESSARY
Exit Fix from RVSM Airspace	NISOR	NECESSARY
Time at Exit Fix	4:01 (or 0401)	NECESSARY
Flight Level at Exit Fix	330	NECESSARY
First Fix Within RVSM Airspace OR First Airway Within RVSM Airspace	MESOK OR G582	OPTIONAL
Time at First Fix	02:25 OR 0225	OPTIONAL
Flight Level at First Fix	330	OPTIONAL
Second Fix Within RVSM Airspace OR Second Airway Within RVSM Airspace	MEVAS OR G577	
Time at Second Fix	02:50 OR 0250	OPTIONAL
Flight Level at Second Fix	330	OPTIONAL
(Continue with as many Fix/Time/Flight-Level entries as are required to describe the flight's movement within RVSM airspace)		OPTIONAL

Information Required for a Flight in Traffic Sample

APPENDIX K -

Description of Models Used to Estimate Technical and Operational Risk

This appendix presents a brief description of the collision risk model forms used to estimate technical and operational risk. The notation used in this appendix is that of "Risk Assessment and System Monitoring[2]," which had been published by the ICAO European, and North Atlantic Office, August 1996. The same notation is employed in the collision risk model development of Appendix B to "Guidance Material on the Implementation of a 300m (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Asia Pacific Region," ICAO Asia and Pacific Office, Bangkok, October 2000. EUR RVSM Mathematical Supplement," Document RVSM 830, European Organization for the Safety of Air Navigation (Eurocontrol), August 2001, describes the collision risk model for RVSM in continental airspace.

Model for Estimation of Technical Risk

The model for the total technical risk, N_{az}, expressed as the sum of three basic types of collision risk, is:

$$N_{az}\text{ (technical)} = N_{az}\text{ (same, technical)} + N_{az}\text{ (opposite, technical)} + N_{az}\text{ (cross, technical)} \quad (1)$$

where the terms on the right side of (1) are defined in Table K1.

Parameter	Description
N_{az} (technical)	Expected number of accidents per aircraft flight hour resulting from collisions due to the loss of planned vertical separation of 1000 ft between aircraft pairs at adjacent flight levels
N_{az} (same, technical)	Expected number of accidents per aircraft flight hour resulting from collisions due to the loss of planned vertical separation of 1000 ft between aircraft pairs flying on the same route in the same direction at adjacent flight levels
N_{az} (opposite, technical)	Expected number of accidents per aircraft flight hour resulting from collisions due to the loss of planned vertical separation of 1000 ft between aircraft pairs flying on the same route in opposite directions at adjacent flight levels
N_{az} (cross, technical)	Expected number of accidents per aircraft flight hour resulting from collisions due to the loss of planned vertical separation of 1000 ft between aircraft pairs flying on crossing routes at adjacent flight levels

Table K1. Technical risk model parameter definitions

Same-route technical risk

2 This material was originally published in NAT Doc 002 which is no longer in print, however, the Supplement is still available.

The model form appropriate for the estimation of same-route technical risk for same- and opposite-direction traffic at adjacent flight levels is:

N_{az}*(same-route, technical)* = N_{az}*(same, technical)* + N_{az} *(opposite, technical)* =

$$P_z(S_z)P_y(0)\frac{\lambda_x}{S_x}\left\{E_z(same)\left[\frac{|\overline{\Delta V}|}{2\lambda_x}+\frac{|\overline{\dot{y}}|}{2\lambda_y}+\frac{|\overline{\dot{z}}|}{2\lambda_z}\right]+E_z(opp)\left[\frac{2|\overline{V}|}{2\lambda_x}+\frac{|\overline{\dot{y}}|}{2\lambda_y}+\frac{|\overline{\dot{z}}|}{2\lambda_z}\right]\right\}$$

(2)

where the parameters of the model presented in (2) are defined in Table K2, below.

CRM Parameter	Description
S_Z	Vertical separation minimum.
$P_z(S_Z)$	Probability that two aircraft nominally separated by the vertical separation minimum S_Z are in vertical overlap.
$P_y(0)$	Probability that two aircraft on the same track are in lateral overlap.
λ_x	Average aircraft length.
λ_y	Average aircraft wingspan.
λ_z	Average aircraft height with undercarriage retracted.
S_x	Length of longitudinal window used to calculate occupancy.
$E_Z(same)$	Same-direction vertical occupancy for a pair of aircraft at adjacent flight levels on same route.
$E_Z(opp)$	Opposite-direction vertical occupancy for a pair of aircraft at adjacent flight levels on same route.
$\overline{\lvert\Delta V\rvert}$	Average relative along-track speed between aircraft on same direction routes.
$\overline{\lvert V\rvert}$	Average absolute aircraft ground speed.
$\overline{\lvert\dot{y}\rvert}$	Average absolute relative cross track speed for an aircraft pair nominally on the same track.
$\overline{\lvert\dot{z}\rvert}$	Average absolute relative vertical speed of an aircraft pair that have lost all vertical separation

Table K2. Same-route technical risk model parameter definitions

The term “overlap” used in Table K2 means that the centres of mass of a pair of aircraft in a given dimension are at least as close as the extent (length, wingspan or height) of the average aircraft in that dimension.

The occupancy parameters, E_z(same) and $E_z(opp)$, in (2) are measures of the relative packing of aircraft at adjacent flight levels on the same route. An alternative measure of such packing is passing frequency, or the number of aircraft per flight hour at an adjacent flight level which pass a typical aircraft. As with occupancies, passing frequencies are defined for traffic at adjacent flight levels operating in the same and opposite directions and represented symbolically as $N_x(same)$ and $N_x(opp)$. The relation between passing frequency and occupancy is shown below:

$$N_x(same) = \frac{\lambda_x}{\hat{S}_x} E_z(same) \frac{\overline{|\Delta V|}}{2\lambda_x}$$

and

$$N_x(opp) = \frac{\lambda_x}{\hat{S}_x} E_z(opp) \frac{|\overline{V}|}{\lambda_x}$$

Estimation of technical risk for pairs of aircraft on crossing routes

The general form for the model to estimate the collision risk between aircraft at adjacent flight levels on routes which cross, as presented in Volume 2 of RGCSP/6, is:

$$N_{az}(cross, technical) = P_z(S_z)\, P_h \left((2\, v_h / \pi\, \lambda_h) + (|z| / 2\, \lambda_z) \right) \qquad (3)$$

where the parameters of the model are defined in table K3.

CRM Parameter	Description
N_{az}(cross, technical)	Number of fatal accidents per flight hour due to loss of vertical separation between aircraft at adjacent flight levels on crossing routes.
S_Z	Vertical separation minimum.
$P_z(S_Z)$	Probability that two aircraft nominally separated by the vertical separation minimum S_Z are in vertical overlap.
P_h	Probability that two aircraft at adjacent flight levels on crossing routes are in horizontal overlap.
v_h	Average relative speed in horizontal plane of a pair of aircraft at adjacent flight levels on crossing routes while they are in horizontal overlap
λ_h	Average diameter of a disk used to represent aircraft horizontal-plane shape.

Table K3. Crossing-route technical risk model parameter definitions

It is important to note that this general form assumes that an RMA has accounted properly for angles of route intersection. A more detailed and complete form of the technical risk model for crossing routes can be found in Appendix A of "EUR RVSM Mathematical Supplement," Document RVSM 830, European Organization for the Safety of Air Navigation (Eurocontrol), August 2001.

Model for Estimation of Risk Due to Operational Errors

The model for estimation of the risk due to operational errors has the same form as (2), above, with one exception. The probability of vertical overlap for aircraft with planned vertical separation S_z, $P_z(S_z)$, is replaced by the following:

$$P_z\ (n \times S_z) = P_z\ (0)\ Pi \qquad (4)$$

where the parameters are defined in table K4.

CRM Parameter	Description
$P_z\ (n \times S_z)$	Probability of vertical overlap arising from errors resulting in deviations of integral multiples of the vertical separation standard, S_Z
$P_z\ (0)$	Probability that two aircraft nominally flying at the same level are in vertical overlap
P_i	Proportion of total system flying time spent at incorrect levels

Table K4. Definitions of parameters required for operational risk model

The proportion of total flying time spent at incorrect levels, P_i, is commonly estimated based on the latest 12 months of operational error data available.

APPENDIX L -

Letter to State authority requesting clarification of the approval State RVSM Approval Status of an Operator

Note: When the RVSM approval status shown in filed flight plan is not confirmed in an RMA's database of State approvals, a letter similar to the following should be sent to the relevant State authority:

<STATE AUTHORITY ADDRESS>

1. The (RMA name) has been established by the (body authorizing RMA establishment) to support safe implementation and use of the Reduced Vertical Separation Minimum (RVSM) in (airspace where the RMA has responsibility) in accordance with guidance published by the International Civil Aviation Organization.

2. Among the other activities, the (RMA name) conducts a comparison of the State RVSM approval status notified by an operator to an air traffic control unit to the records of State RVSM approvals available to us. This comparison is considered vital to ensuring the continued integrity of RVSM use.

3. This letter is to advise that an operator which we believe is on your State registry provided notice of State RVSM approval which is not confirmed by our records. The details of the occurrence are as follows:

Date:
Operator name:
Aircraft flight identification:
Aircraft type:
Registration mark:
ATC unit receiving notification:

4 We request that you advise this office of the RVSM approval status of this operator. In the event that you have not granted RVSM approval to this operator, we request that you advise this office of any action which you propose to take.

Sincerely,

(RMA official)

APPENDIX M -

Guidance to Reduce Minimum Monitoring Requirements

This guidance is provided so that an RMA may judge if they need to reduce minimum monitoring requirements based on their data set.

The four criteria used to determine initial monitoring requirements or targets are:

1. **The value of the |mean| + 3stdev < 200 feet**

TGL 6/91-RVSM states that the ASE for an aircraft group when the aircraft are operating in the basic flight envelope should meet the criteria of |mean| + 3stdev < 200 ft. This performance standard is more strict than that set for aircraft in the total flight envelope (|mean| + 3stdev < 245 ft). It should be noted that the latter is also the ICAO group requirement.

It is assumed that all monitoring data was collected while aircraft were flying the basic flight envelope. In addition, it is also assumed that if observed ASE monitoring data shows that a monitoring group is meeting the standard for the basic flight envelope then they are likely to satisfy |mean| + 3stdev < 245 feet when operating in the total flight envelope. As such, when deciding whether or not a target can be reduced the stricter criteria for the basic flight envelope is applied.

To fully satisfy this criterion the upper limit of a two-sided 95% confidence interval for the standard deviation must also fall within the upper bound of the criteria for the basic flight envelope. This was applied in the previous assessment but was not explicitly stated. It is mentioned here for completeness.

2. **Percentage of operator population with at least one measure**.

In addition to the first criteria, it is necessary to ensure that the monitoring data is representative of the total population. It is assumed that it is necessary for at least 75% of the total operators to have at least one of their aircraft monitored to provide a good representation of the entire operator population. In addition, the operator population must contain measures that are from the European monitoring program.

3. **Individual aircraft performance must be consistent with the group**.

For each monitoring classification, the individual aircraft means are compared to the classification mean +/- 1.96 times the between airframe standard deviation with a correction factor. The correction factor is dependent on the number of repeated samples and corrects for any bias in the estimation of standard deviation. The individual aircraft means should fall within these upper and lower bounds in 95% of the cases. This information is not provided in this report however, can be made available upon request.

An additional examination is made of the plots of individual aircraft standard deviation against the pooled estimate of the within airframe standard deviation with a 95% two-sided confidence interval. This is based on the assumption that the within airframe variation of ASE is the same for all the aircraft of a classification. These plots are not provided in this report however; they can be made available upon request.

4. **Each Operator Has a Fleet that is Meeting Individual Measurement Requirements**

TGL 6/91-RVSM states that the absolute ASE of any measure for a non-group aircraft must not exceed 160 ft for worst-case avionics. On the assumption that a group aircraft should perform equal to or better than a non-group aircraft, the absolute maximum ASE value was examined for all operator-monitoring group combinations. To account for any measurement system error, an additional 30 ft was considered when examining measures.

It was accepted that some of the fleet would be outside of these limits however if this grew to greater than 10% of the fleet then it is considered not appropriate to reduce the monitoring requirement to as low at 10%. To cater for small fleets, an operator that has at least 2 aircraft showing performance worse than 190 ft and these constitute at least 10% of the operator's measured fleet is considered to have failed this criteria.

APPENDIX N -

Information On The Merits Of HMU And GMU Monitoring Systems

HEIGHT MONITORING SYSTEMS

The Height Monitoring Unit (HMU) is a fixed ground based system whose technical capability and requirements are discussed in the following section. Its main advantage is the ability to capture a large amount of data which can be made available for analysis rapidly without manual intervention. The main disadvantage is that it requires a flight within range of the HMU.

The GPS Monitoring Unit (GMU) is a carry on system placed on an aircraft for a single flight. Its main advantage is the ability to target an individual aircraft for monitoring during normal operations without requiring that the aircraft fly in a particular portion of airspace. The GMU is a key element in the GPS-based Monitoring System (GMS). The main disadvantages of the GMS are the requirements for cooperation from the target aircraft and significant intervention in operation and data extraction.

The HMU is used to monitor aircraft height-keeping performance in the North Atlantic and European Regions. The GMS is used in these Regions, as well as in several others.

GROUND BASED HEIGHT MONITORING UNITS (HMUs)

An HMU is a network of ground based receiver stations which receive SSR transponder signals from aircraft replying to interrogations from one (or more) radar stations. They process the information from these replies and combine it with meteorological data to evaluate the Total Vertical Error (TVE) of each aircraft passing within the area of coverage. The signal processing equipment, the Height Monitoring Equipment (HME), determines the geometric height of aircraft by comparing the time of reception of the SSR signals, from the target aircraft, at each of the different receiver stations. The HME outputs the 3D position and associated identification (Mode A, C or S as appropriate) once per second.

The HMU system operates in a passive manner, in the sense that the system does not interrogate aircraft in the manner of secondary surveillance radar. Thus, the HME receives random replies from the aircraft as a result of uncorrelated interrogations. The replies have to be sorted, the form of reply which has been received (Mode A or C) has to be established, and those from the same aircraft chained to allow the smoothed value of the geometric height to be compared with the geometric height of the assigned flight levels and the reported flight level (Mode C). To do this, meteorological data are provided by MET offices. These data are further refined by evaluating the trends in the performance of the ensemble of aircraft being monitored during a particular time interval. This process is undertaken by the Total Vertical Error Measuring Unit (TMU). The TMU and HME are together termed the HMU.

The size of the of the HMU coverage area and the number of HMUs needed depends upon the airspace route structure and the number of aircraft required to be monitored. For example the NAT environment has gateway locations ensuring a large proportion of the aircraft will fly over a single HMU during their normal operations. No such gateway locations exist for European operations which would could allow such a high coverage from a single HMU.

To provide cover over a number of air routes, for example as shown in Figure 1, and to avoid the need to inhibit ATC freedom, the HMUs necessary for the European RVSM programme need an operational a radius of approximately 45 N. Miles. To maintain the system accuracy over this area the HMU requires a five-site system with a distance of approximately 25 N Miles between the central station and the remaining 4 receiver stations arranged in a square around the central site.

The preferred sites identified for the European HMU were airfields and other installations owned by the ATS providers. The use of such sites would simplify procurement procedures and reduce the risk associated with application for planning permission. The second set of sites identified were sites where line-of-sight can be physically obtained. These are mainly communication towers.

The GPS-based Monitoring System (GMS)

The GMS consists of a GMU and an off-line data procession system. The GMU is a portable unit and, depending upon the supplier, consists of one or two GPS receivers, a laptop computer for the processing and data storage, and two separate GPS antennas. The antennas are attached to aircraft windows using suction pads. The GMU is either battery powered or has a power supply system to allow connection to the aircraft's power supply. After completion of the flight, the recorded GPS data is transferred to a central site where, using Differential GPS post processing, the aircraft geometric height is determined. The height data are then compared with the geometric height of the assigned flight levels as estimated from data provided by the MET offices. It is important to note that the MET data cannot be refined in the manner described for the HMU operation. SSR Mode C data, as recorded by the GMU or obtained from ATC providers as radar data output, are then combined with the height data and flight level heights to determine the aircraft altimetry system errors.

The analysis of the GMU data can be made available within a few days but this can extend up to a few weeks, dependent upon the logistics of the use of the GMU and the retrieval of the data.

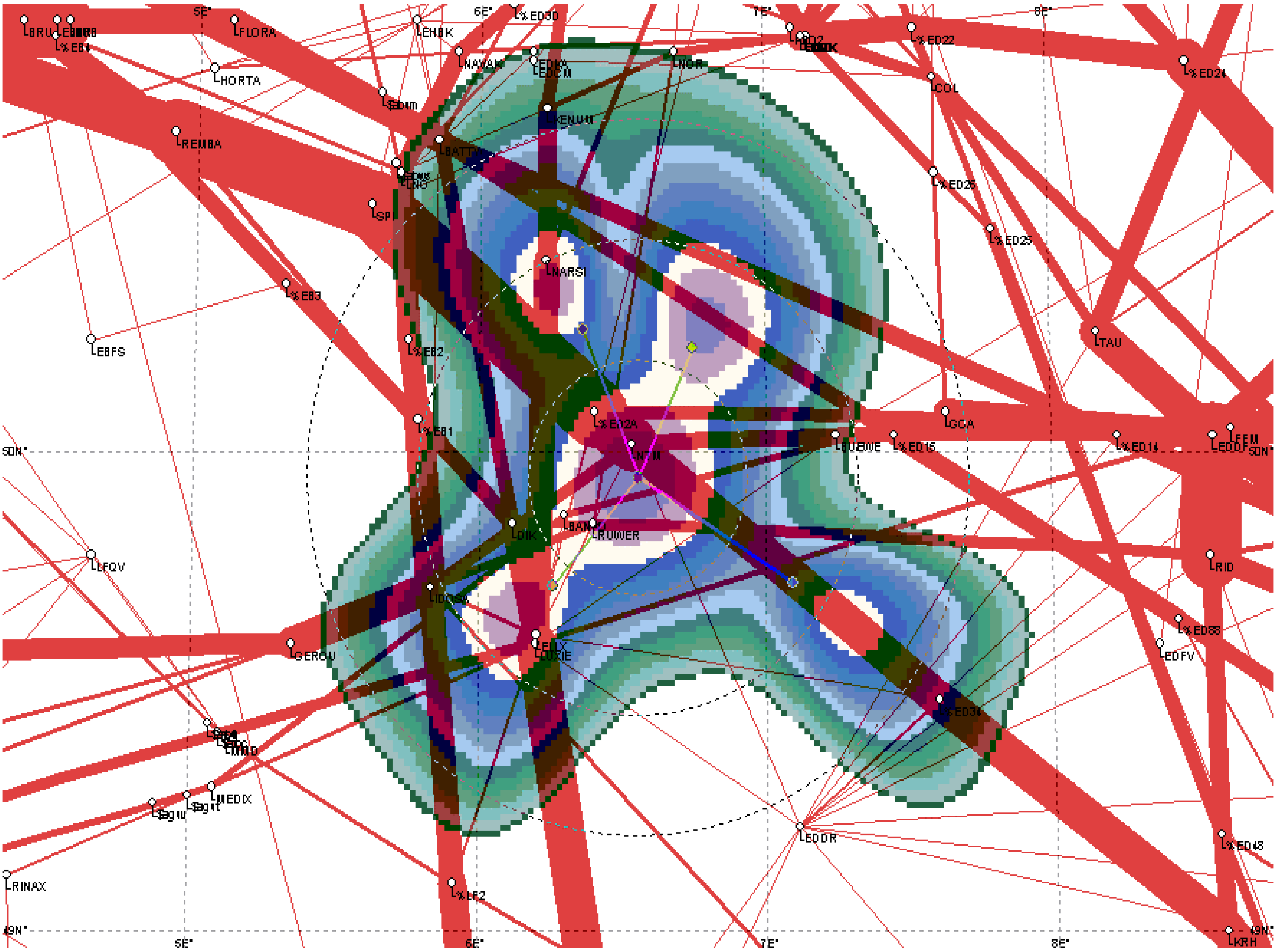
To monitor a specific airframe, the GMU may be installed on the aircraft flight deck or within the cabin. It may require a power input and the antennas will need to be temporarily attached to the aircraft windows. This process may require appropriate certification of the GMU for the aircraft types in which it has to be installed. It also requires appropriate expertise for the installation and operation and active support from operators and pilots.

***ADVANTAGES* - DISADVANTAGES**

In developing a monitoring system, an RMA is advised to consider carefully the goals of the monitoring program, the flows of traffic within the airspace where the RVSM will be implemented and the availability of applicable monitoring data from other Regions. With this information, an RMA can then examine the merits of the HMU and GMs as discussed above, which are summarised as follows:-

HMS		GMS
Measures all aircraft in the coverage area	←→	Aircraft individually targetable
Refinement of FL geometric height possible	←→	Refinement not possible

Large data set captured per day	←→	Small data set captured per day
Expensive to buy and deploy	←→	Inexpensive to buy
Inexpensive to operate	←→	Expensive to operate
Operation is transparent to aircraft	←→	Possible difficulties to install on flight deck
Trend detection of height-keeping performance for a/c type groups	←→	Uncertain trend detection



– END –

Figure 1. Theoretical accuracy of Nattenheim HME