GUIDANCE MATERIAL ON THE IMPLEMENTATION

OF A 300 m (1000 ft) VERTICAL SEPARATION MINIMUM

IN THE EUROPEAN RVSM AIRSPACE

Version 3

Prepared by the ICAO European and North Atlantic Office
on behalf of the European Air Navigation Planning Group (EANPG)
FOREWORD


The Guidance material will be updated from time to time by the EANPG Programme Coordinating Group (COG) and amendments will be issued accordingly.

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AMENDMENT HISTORY

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**ATTACHMENT A - TABLES OF CRUISING LEVELS** .............................................................. A- Error! Bookmark not defined.
## LIST OF DEFINITIONS

The following definitions are provided in order to clarify certain specialised terms used in this document:

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<th>Term</th>
<th>Definition</th>
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<tr>
<td><strong>Altimetry System Error (ASE)</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Assigned Altitude Deviation (AAD)</strong></td>
<td>The difference between the transponded Mode C altitude and the assigned altitude/flight level.</td>
</tr>
<tr>
<td><strong>Automatic Altitude Control System</strong></td>
<td>Any system which is designed to automatically control the aircraft to a referenced pressure altitude.</td>
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<tr>
<td><strong>General Air Traffic (GAT)</strong></td>
<td>Flights conducted in accordance with the rules and provisions of ICAO.</td>
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<tr>
<td><strong>Collision Risk</strong></td>
<td>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.</td>
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<td></td>
<td>(Note - one collision is considered to produce two accidents.)</td>
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<td><strong>Flight Level Allocation Scheme (FLAS)</strong></td>
<td>The scheme whereby specific flight levels may be assigned to specific route segments within the route network.</td>
</tr>
<tr>
<td><strong>Height-Keeping Capability</strong></td>
<td>Aircraft height-keeping performance which can be expected under nominal environmental operating conditions with proper aircraft operating practices and maintenance.</td>
</tr>
<tr>
<td><strong>Height-Keeping Performance</strong></td>
<td>The observed performance of an aircraft with respect to adherence to cleared flight level.</td>
</tr>
<tr>
<td><strong>Operational Air Traffic (OAT)</strong></td>
<td>Flights which do not comply with the provisions stated for GAT and which rules and procedures have been specified by appropriate authorities.</td>
</tr>
<tr>
<td><strong>Passing Frequency</strong></td>
<td>The frequency of events in which two aircraft are in longitudinal overlap when travelling in the opposite or same direction on the same route at adjacent flight levels and at the planned vertical separation.</td>
</tr>
<tr>
<td><strong>Position Error</strong></td>
<td>See static source error.</td>
</tr>
<tr>
<td><strong>Reduced Vertical Separation Minimum (RVSM)</strong></td>
<td>A vertical separation minimum of 300 m (1 000 ft) which is applied between FL 290 and FL 410 inclusive, on the basis of regional air navigation agreements and in accordance with conditions specified therein.</td>
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**RVSM Approval**

The approval that is issued by the appropriate authority of the State in which the Operator is based or of the State in which the aircraft is registered. To obtain such RVSM approval, Operators shall satisfy the said State that:

1) aircraft for which the RVSM Approval is sought have the vertical navigation performance capability required for RVSM operations through compliance with the criteria of the RVSM Minimum Aircraft System Performance Specification (MASPS);

2) they have instituted procedures in respect of continued airworthiness (maintenance and repair) practices and programmes; and

3) they have instituted flight crew procedures for operations in the EUR RVSM airspace.

**RVSM Entry Point**

The first reporting point over which an aircraft passes or is expected to pass immediately before, upon, or immediately after initial entry into EUR RVSM airspace, normally the first reference point for applying a 300 m (1 000 ft) vertical separation minimum between RVSM approved aircraft.

**RVSM Exit Point**

The last reporting point over which an aircraft passes or is expected to pass immediately before, upon, or immediately after leaving EUR RVSM airspace, normally the last reference point for applying a 300 m (1 000 ft) vertical separation minimum between RVSM approved aircraft.

**State Aircraft**

Aircraft used in Military, Customs, and Police services shall be deemed to be State Aircraft (Reference - ICAO Convention on International Civil Aviation, Article 3 (b)).

**Static Source Error**

The difference between the pressure sensed by the static system at the static port and the undisturbed ambient pressure.

**Static Source Error Correction (SSEC)**

A correction which may be applied to compensate for the static source error associated with an aircraft.

**Target Level of Safety (TLS)**

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

**Total Vertical Error (TVE)**

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

**Vertical Separation**

Vertical separation is the spacing provided between aircraft in the vertical plane to avoid collision.
The acronyms listed hereunder have been chosen from those which are specifically related to activities of the EANPG and/or are most frequently found in this report in order to assist in its reading.

<table>
<thead>
<tr>
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<th>Definition</th>
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<tr>
<td>AAD</td>
<td>Assigned Altitude Deviation</td>
</tr>
<tr>
<td>ACC</td>
<td>Area Control Centre</td>
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<tr>
<td>ADS</td>
<td>Automatic Dependent Surveillance</td>
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<tr>
<td>AIC</td>
<td>Aeronautical Information Circular</td>
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<tr>
<td>AIP</td>
<td>Aeronautical Information Publication</td>
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<tr>
<td>ALARP</td>
<td>As Low As Reasonably Practical</td>
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<tr>
<td>AFI</td>
<td>ICAO Africa Region</td>
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<tr>
<td>AMC</td>
<td>Acceptable Means of Compliance</td>
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<td>ANT</td>
<td>EUROCONTROL Air Navigation Team</td>
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<tr>
<td>AOC</td>
<td>Air Operator’s Certificate</td>
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<td>APDSG</td>
<td>EUROCONTROL ATM Procedures Development Sub-Group</td>
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<tr>
<td>ASE</td>
<td>Altimetry System Error</td>
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<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATFM</td>
<td>Air Traffic Flow Management</td>
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<tr>
<td>ATM</td>
<td>Air Traffic Management</td>
</tr>
<tr>
<td>ATS</td>
<td>Air Traffic Services</td>
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<tr>
<td>CDB</td>
<td>Central Data Base</td>
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<tr>
<td>CFL</td>
<td>Cleared Flight Level</td>
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<tr>
<td>CRM</td>
<td>Collision Risk Model</td>
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<tr>
<td>EANPG</td>
<td>European Air Navigation Planning Group</td>
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<tr>
<td>EATCHIP</td>
<td>European Air Traffic Control Harmonisation and Integration Programme</td>
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<tr>
<td>EATMP</td>
<td>European Air Traffic Management Programme</td>
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<tr>
<td>ECAC</td>
<td>European Civil Aviation Conference</td>
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<tr>
<td>EUR</td>
<td>ICAO European Region</td>
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<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
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<tr>
<td>FIR</td>
<td>Flight Information Region</td>
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<tr>
<td>FL</td>
<td>Flight Level</td>
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<tr>
<td>FLAS</td>
<td>Flight Level Allocation Scheme</td>
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<tr>
<td>FLOS</td>
<td>Flight Level Orientation Scheme</td>
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<td>GAT</td>
<td>General Air Traffic</td>
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<tr>
<td>GMS</td>
<td>GPS Monitoring System</td>
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<tr>
<td>GMU</td>
<td>GPS Monitoring Unit</td>
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</table>
GPS      Global Positioning System
GSPS     Global System Performance Specification
HMU      Height Monitoring Unit
ICAO     International Civil Aviation Organisation
IFPS     Integrated Initial Flight Plan Processing System
IFR      Instrument Flight Rules
JAA      Joint Aviation Authorities
JAR      Joint Aviation Requirements
MASPS    Minimum Aircraft System Performance Specification
MEL      Minimum Equipment List
MMEL     Master Minimum Equipment List
MNPS     Minimum Navigation Performance Specifications
NAT      ICAO North Atlantic Region
NAT SPG  North Atlantic Systems Planning Group
OAT      Operational Air Traffic
QNH      Altimeter sub-scale setting to obtain elevation when on the ground
QFE      Atmospheric pressure at aerodrome elevation (or runway threshold)
RGCSP    Review of the General Concept of Separation Panel
RPG      Regional Planning Group
RPL      Repetitive Flight Plan
RTA      Real Time Alert
RTF      Radiotelephony
RVSM     Reduced Vertical Separation Minimum of 300 m (1000 ft) between FL 290 and FL 410 inclusive
SD       Standard Deviation
SDB      State Data Base
SSEC     Static Source Error Correction
SSR      Secondary Surveillance Radar
TGL      Temporary Guidance Leaflet
TLS      Target Level of Safety
TVE      Total Vertical Error
UAC      Upper Area Control Centre
UIR      Upper Information Region
VFR      Visual Flight Rules
VSM      Vertical Separation Minimum
1. INTRODUCTION

1.1 Background

1.1.1 The ICAO Review of the General Concept of Separation Panel, at its fourth meeting (RGCSP/4) in 1980, concluded that the potential benefits of the reduction of the vertical separation minimum (VSM) above FL 290, from 600 m (2000 ft) to 300 m (1000 ft), were so great that States should be encouraged to undertake the major studies and evaluations necessary to determine the feasibility of this measure, despite the considerable cost, time and effort that would be entailed.

1.1.2 In 1982, under the overall guidance of the RGCSP, several States initiated comprehensive work programmes to examine the feasibility of reducing the VSM above FL 290. Studies were carried out by Canada, Japan, the former Union of the Soviet Socialist Republics (USSR), the United States of America (USA), and four Member States of EUROCONTROL - France, the former Federal Republic of Germany, the Kingdom of the Netherlands, and the United Kingdom - in an extensive co-operative venture which was coordinated by the EUROCONTROL Agency.

1.1.3 The primary objective of these studies was to decide whether the global implementation of the Reduced VSM (RVSM) would:

a) satisfy predetermined safety standards;

b) be technically and operationally feasible; and

c) provide a positive Benefit to Cost ratio.

1.1.4 The studies employed quantitative methods of risk assessment to support operational decisions concerning the safety and feasibility of reducing the VSM. The process of risk assessment consisted of two elements:

a) Risk estimation, which involves the development and use of methods and techniques with which the actual level of risk of an activity (e.g. operations in an RVSM environment) can be estimated; and

b) Risk evaluation, which concerns the determination of the maximum level of risk, associated with the particular activity, which can be tolerated in a system which is considered to be safe. The level of risk that is deemed to be tolerable is termed the Target Level of Safety (TLS).

1.1.5 The basis of the risk estimation process was the determination of the accuracy of the height-keeping performance of the aircraft population operating at/above FL 290. This was achieved through the use of high precision radar to measure the geometric height of individual aircraft in straight and level flight. This height was then compared with the geometric height of the flight (pressure) level to which the aircraft had been assigned, in order to determine the height-keeping deviation or Total Vertical Error (TVE) of the aircraft in question.

1.1.6 TVE data were collected for a representative sample of the aircraft population. This data together with a knowledge of other key parameters of the Reich Collision Risk Model (CRM) (e.g. traffic density, airspace characteristics, and the lateral track keeping accuracy of the aircraft population) made it possible to estimate the risk of a mid-air collision as a consequence of vertical navigation errors of aircraft, in straight and level flight, to which procedural vertical separation had been correctly applied. It is important to emphasise that the TLS adopted by the RGCSP, for risk assessment purposes, applied only to those vertical
errors which were the result of some shortcoming of the altimetry system (height-keeping capability) of an aircraft. This assessment TLS did not encompass the contributions to vertical collision risk of other sources of error such as emergency descents or human error.

1.1.7 Many different approaches were considered in the determination of an appropriate range of TLS values. These included the derivation of a "Vertical" TLS which would tolerate the risk of an en-route mid-air collision, as a consequence of a loss of vertical separation, once in a philosophically acceptable period of time, e.g. approximately every 150 years (2 x the theoretical life span). However the primary, and traditional, approach employed was first to derive accident rates from historical data, from global sources. These rates were then predicted forward, incorporating the essential flight safety requirement of a constant annual reduction of accident rates, in order to define a tolerable level of risk from all types of accident for the year 2000. This total risk was then broken down and apportioned to the various causes of risk in order to derive a risk budget, in the form of a TLS, relating to the future global application and use of RVSM.

1.1.8 The resultant values for the TLS ranged between $1 \times 10^{-8}$ and $1 \times 10^{-9}$ fatal accidents per flight hour. On the basis of these figures, the RGCSP employed an assessment TLS of $2.5 \times 10^{-9}$ fatal accidents per aircraft flight hour to determine technical feasibility of a $1000$ ft VSM above FL 290 and also to develop the aircraft height-keeping capability requirements to support operations in a $1000$ ft VSM.

1.1.9 Using this assessment TLS of $2.5 \times 10^{-9}$ fatal accidents per aircraft flight hour, RGCSP/6 concluded that a $300$ m (1000 ft) VSM above FL 290 was technically feasible. This technical feasibility referred to the fundamental capability of aircraft height-keeping systems which could be built, maintained, and operated in such a way that the expected, or typical, performance was consistent with safe implementation and use of a $300$ m (1000 ft) VSM above FL 290. In reaching this conclusion about technical feasibility, the panel found it necessary to establish:

a) airworthiness performance requirements embodied in a comprehensive Minimum Aircraft System Performance Specification (MASPS) for all aircraft utilising the reduced separation;

b) new operational procedures; and

c) a comprehensive means of monitoring the safe operation of the system.

1.1.10 At the seventh meeting of the RGCSP (November 1990), the Panel completed the Global Guidance Material for the Implementation of a $300$ m (1000 ft) Reduced Vertical Separation Minimum (RVSM). This material was approved by the ICAO Air Navigation Commission in February 1991 and was published as ICAO Doc 9574 - AN/934 - First Edition - 1992. The main purpose of the material was to provide Regional Planning Groups (RPGs) with a basis for the development of documents, procedures and programmes to enable the introduction of the RVSM, within their particular region, in accordance with the criteria, requirements and methodology outlined in the report of RGCSP/6 (Doc 9536).

1.1.11 The Panel drew particular attention to the need for further detailed work by RPGs to:

a) establish the specific conditions for the implementation of the RVSM in each region;

b) undertake any necessary amendment to the Regional Supplementary Procedures (Doc 7030); and

c) employ operational judgement in the determination of the tolerable level of risk attributable to those error causes not encompassed by the global TLS (i.e. assessment TLS of $2.5 \times 10^{-9}$).

1.1.12 The Panel also considered that the NAT Region would be suitable for the early implementation of the RVSM because of the essentially uni-directional flow of the NAT traffic and the
better than average height-keeping accuracy of the minimum navigation performance specifications (MNPS) approved aircraft population.

1.2 Introduction of RVSM in the NAT Region

1.2.1 In parallel with the work of RGCSP, the North Atlantic Systems Planning Group (NAT SPG) initiated studies in May 1990 (NAT SPG/26) to examine the application of the RVSM in the NAT Region. At its twenty-seventh meeting (June 1991), the NAT SPG agreed that:

a) RVSM should be effected within the dimensions of the existing NAT MNPS airspace;

b) the transition area should have a vertical extent of FL 290 to FL 410, inclusive; be contained within horizontal dimensions determined by provider States either individually or in consultations; be adjacent to, overlapping or within RVSM airspace and have, wherever practicable, radar coverage and direct controller/pilot communications;

c) it would be necessary to adopt a TLS which encompassed the vertical risk from all sources of error (i.e. the equipment errors for which the MASPS had been developed and also pilot and controller operational errors). Accordingly it was agreed that the TLS should be increased from $2.5 \times 10^{-9}$ to $5 \times 10^{-9}$. The NAT SPG concluded (NAT Conclusion 27/22) that:

i) the TLS for collision risk in the vertical dimension due to all causes be $5 \times 10^{-9}$ fatal accidents per flight hour and that the overall collision risk in the vertical plane be assessed against this TLS; and

ii) the TLS would not be partitioned into separate components for different types of risk. However, assessments of height-keeping performance would need to be conducted with reference to a safety constraint of $2.5 \times 10^{-9}$, as this was the value which had been used to derive the MASPS.


1.3 Preparatory Work for the Introduction of RVSM in Europe

1.3.1 The work of EUROCONTROL, in co-ordinating the contribution of the European States to the RGCSP studies, had continued to support the NAT SPG RVSM programme and also to develop an initial assessment of the practicality of the implementation of RVSM in European airspace.

1.3.2 At the ICAO Special European Regional Air Navigation Meeting (SPEC EUR RAN) held in Vienna in September 1994, as a result of representations by EUROCONTROL and the User Organisations, the following text was agreed:

"The Meeting endorsed the objectives of capacity and economy benefits associated with future implementation of a 300 m (1000 ft) reduced VSM in the EUR Region, and therefore concluded that such implementation planning should be progressed as a priority item. It was recognised that a number of complex issues required to be resolved, including meteorological and topographical questions, aircraft equipment fit and air traffic control implications, which at the time of the Meeting precluded a definition of firm time-scales for implementation. However, a programme for implementation in the earliest possible
timeframe should be pursued actively. The Meeting emphasised that implementation planning should be carried out by the [ICAO] EANPG and should be fully co-ordinated for the entire area of future application, and should take full account of the work carried out by the Review of the General Concept of Separation Panel (RGCSP), North Atlantic Systems Planning Group (NAT SPG), EUROCONTROL and States in the Region. Co-ordination with States outside the EUR Region might also be necessary due to the location of the transition areas. Concerted effort and manpower would be required to accomplish the task” (paragraph 3.8.4. - ICAO Doc 9639 SP EUR (1994)).

1.3.3 Within this remit, a work programme was developed to further the implementation of RVSM in the airspace of the Member States of the European Civil Aviation Conference (ECAC) and other non-ECAC States with an operational interface to the ECAC area, hitherto described in this document as the European RVSM airspace. The programme was developed and co-ordinated under the auspices of EUROCONTROL as an essential element of the European Air Traffic Control Harmonisation and Implementation Programme (EATCHIP), in consultation with the ICAO European and North Atlantic Office, Paris. After consultation with States and other stakeholders, the target date for RVSM implementation in European airspace was agreed as 24 January 2002.

1.3.4 The initial planning was undertaken by sub-groups of the EUROCONTROL Airspace and Navigation Team (ANT); with the development of the MASPS and the associated airworthiness documentation being the responsibility of the JAA. The ANT agreed to adopt the TLS of $5 \times 10^{-9}$ fatal accidents per flight hour, and the underlying philosophy (sub-paragraph 1.2.1 (c) refers), which had been applied in the NAT Region, together with objectives of the EATCHIP Safety Policy. It was also agreed, by JAA, that no changes in the technical content of the MASPS would be necessary and that existing MASPS documentation could be amended and expanded to incorporate operations in the European RVSM airspace.

1.4 Scope and Purpose of the Document

1.4.1 This document seeks to address, and to provide guidance on, all aspects of the implementation and operation of a 300 m (1000 ft) vertical separation minimum, between FL 290 and FL 410 inclusive, within the European RVSM airspace. Where authoritative and more detailed material has been published, this document will summarise, and give the appropriate cross-references to, such material.

1.4.2 The purpose of this guidance material is therefore to:

a) consolidate the ICAO Doc 9574 and ICAO NAT Doc 002 material on the implementation of a 300 m (1 000 ft) VSM, in order to meet the particular demands of the European RVSM airspace;

b) complement the material issued by the JAA/FAA/Other State Airworthiness Authorities on the RVSM MASPS, Approval Procedures, and Flight Crew Operating Procedures and by EUROCONTROL;

c) provide guidance to State Aviation Authorities on the measures necessary to ensure that the criteria and requirements are met within their various areas of responsibility (e.g. provision of ATC services, airworthiness approvals and monitoring of airspace);

d) provide information to operators to enable them to comply with requirements for RVSM operations, and to assist in the development of operating manuals and flight crew procedures; and

e) form a basic guidance document on all aspects of the implementation and operation of RVSM.
2. REQUIREMENTS AND WORK PROGRAMME

2.1 Basic System Requirements

2.1.1 The principal requirement for the introduction and continued operation of the 1000 ft VSM in the European RVSM airspace is that the system can be shown to be acceptably safe. This condition gives rise to the following basic requirements:

a) Operators intending to conduct flights within the notified RVSM airspace shall require an RVSM Approval issued by the appropriate authority of the State in which the Operator is based, or of the State in which the aircraft is registered. To obtain such RVSM approval, Operators shall satisfy the said State that:

i) aircraft for which the RVSM Approval is sought have the vertical navigation performance capability required for RVSM operations through compliance with the criteria of the RVSM Minimum Aircraft System Performance Specification (MASPS) [e.g. JAA Temporary Guidance Leaflet No. 6, Revision 1 (TGL No. 6, Rev 1)] and appropriate State airworthiness procedures. More detailed guidance is provided in Part 3 of this document.

ii) they have instituted procedures in respect of continued airworthiness (maintenance and repair) practices and programmes.

iii) they have instituted flight crew procedures for operations in the EUR RVSM airspace. The procedures should be based on the material set out in Part 6 of this document.

The responsibility for gaining the necessary approval must rest with the aircraft operator. State Aviation Authorities, however, will be expected to maintain regular checks and records of the approvals which they have granted. The relevant guidance is detailed in Part 4 of this document.

b) Flight Crew should operate the aircraft in accordance with recommended operating procedures.

c) The Air Traffic Services (ATS) Provider States should institute the ATC procedures necessary to support RVSM. The procedures to be used are set out in the EUROCONTROL document "ATC Manual for a Reduced Vertical Separation Minimum (RVSM) in Europe", and are described in Part 7 of this document.

d) Regional procedures should be established to monitor that the requirements of the Global System Performance Specification (described in sub-paragraph 2.2 below) are satisfied in order to ascertain that the technical TLS is being met. Additional information with regards to the monitoring is contained in Part 10 of this document.

2.2 Requirements of the Global System Performance Specification (GSPS)

2.2.1 The Global System Performance Specification defines critical CRM parameters which characterise a “worst case” airspace environment in terms of vertical collision risk. These parameters were set at levels which were expected to be representative of an RVSM environment until at least the year 2005. The specification also defines the height-keeping performance which will be required from aircraft to ensure that the collision risk, in such a worst case airspace, would not exceed the technical TLS apportionment of
2.5 x 10^{-9} fatal accidents per flight hour. The quantitative statement of the Global System Performance Specification is:

a) a passing frequency equal to or less than the equivalent of 2.5 opposite-direction passings per aircraft flight hour;

b) a standard deviation of the lateral path-keeping error of the aircraft population equal to or greater than 0.3 NM; and

c) a probability that two aircraft, nominally separated by 1000 feet, will be in vertical overlap, $P_z(1000)$, equal to or less than $1.7 \times 10^{-8}$.

2.2.2 Items (a) and (b) above may be combined into an equivalent, but more generally applicable quantitative statement, namely that the frequency of opposite direction passing events involving lateral overlap does not exceed 0.145 passings per aircraft flying hour. For monitoring purposes, a trade-off between the GSPS parameters may be considered, provided $P_z(1000)$ does not exceed $1.7 \times 10^{-8}$.

2.2.3 The global height-keeping performance specification was derived in order to satisfy the requirement, at sub-paragraph 2.2.1 (c) above. The specification entails the simultaneous satisfaction of the following four requirements:

a) the proportion of TVE in excess of 300 ft in magnitude is less than $2.0 \times 10^{-3}$;

b) the proportion of TVE in excess of 500 ft in magnitude is less than $3.5 \times 10^{-6}$;

c) the proportion of TVE in excess of 650 ft in magnitude is less than $1.6 \times 10^{-7}$;

d) the proportion of TVE between 950 and 1050 ft in magnitude is less than $1.7 \times 10^{-8}$.

2.2.4 The MASPS was developed to ensure that the above conditions are met by all aircraft which operate in RVSM airspace. The requirements of the MASPS are detailed in JAA Temporary Guidance Leaflet No. 6, Revision 1 (TGL No. 6, Rev.1), and are summarised in Part 3 of this document. The various means of monitoring that the requirements of the Global System Performance Specification are being met are outlined in Part 10 of this document.

2.2.5 It should be emphasised that compliance with the Global System Performance Specification alone will not be sufficient to ensure that the RVSM airspace system is acceptably safe. The additional sources of error must also be monitored and the contribution of these errors to the overall collision risk must be assessed. These operational considerations are also addressed in Part 10 of this document.

2.3 RVSM Work Programme

2.3.1 The initial planning for the implementation of RVSM in European airspace was accomplished in accordance with the Implementation Strategy described in ICAO Doc 9574.

2.3.2 This section describes the elements of the initial planning process and summarises the future work programme.
2.3.3 Initial Planning

a) The ICAO SPEC EUR RAN Meeting, held in Vienna in 1994, “endorsed the objectives of capacity and economy benefits associated with [the] future implementation of a 300 m (1000 ft) reduced VSM in the EUR Region, and therefore concluded that such implementation planning should be progressed as a priority item”. This planning was undertaken by EUROCONTROL, initially as a part of EATCHIP, later within the European Air Traffic Management Programme (EATMP). An initial estimated date for RVSM implementation was November 2001.

b) The consequent work of the specialist groups, operating under the remit of the ANT, was focused on four inter-related areas:

i) Safety Considerations
   - Confirmation of the process and parameters of the CRM
   - Assessment and Evaluation of system risk
   - Confirmation of the overall TLS
   - Possible use of Real Time Alerts (RTAs)
   - Determination of the lateral track keeping accuracy of aircraft
   - Assessment of the required level and means of Monitoring
   - Recommendations on number/location of Height Monitoring Units (HMUs)
   - Evaluation of the Global Positioning System Monitoring Unit (GMU)
   - Assessment of the safety of the future RVSM airspace
   - Validation of RVSM ATC procedures
   - Validation of ATS Systems adaptations required to support RVSM

ii) Airspace Considerations
   - Real-time simulations of RVSM operations in a European environment
   - Determination of the optimum Flight Level Orientation Scheme (FLOS) for use in the European RVSM airspace
   - Impact of RVSM on Controller workload
   - General ATC Procedures for Non-RVSM approved State aircraft operating as General Air Traffic (GAT) within the RVSM airspace
   - Procedures for State Aircraft operating as Operational Air Traffic (OAT), Crossing ATS Routes, within the RVSM airspace
   - Flight Planning procedures
• Inter-centre co-ordination procedures
• Contingency procedures
• Transition procedures
• Phraseology

iii) Aircraft Considerations
• Co-operation with JAA on the development of the European RVSM MASPS
• Notification of requirements to Operators

iv) Cost Benefit Considerations
• Confirmation of the initial assessment of the positive Benefit to Cost Ratios

c) The end of the initial phase of the implementation strategy was marked by the “Go Ahead” decision date of June 1997. At this point the ANT reviewed the progress made on the RVSM Programme and recommended that work should continue towards implementation, which was consequently confirmed by the Committee of Management. Following this, the EUROCONTROL Provisional Council requested the set-up of an adequate programme management structure to run the programme effectively and to confirm with States and other RVSM stakeholders a feasible target date for RVSM implementation to which full commitment could be given. In the meantime the required RVSM programme preparation activities continued. In April 1999, the Provisional Council approved the RVSM Master Plan, which set out all key elements of the EUR RVSM Programme, with an implementation date of 24 January 2002.

d) From the point of view of the Operators, the RVSM Master Plan required that they should plan to equip their aircraft to satisfy the requirements of the MASPS and to gain State approval for RVSM operations. It will be necessary for a high percentage of the aircraft population to have such approval as the first step in the Airspace User Preparation and Performance Verification process (Sub Programme - P1) of the RVSM work programme.

2.3.4 Work Programme

a) The EUR RVSM Programme, which requires close co-ordination and co-operation with ICAO and JAA, consists of five sub-projects/programmes which include the following tasks:

i) Project P0 - RVSM Programme Validation & Set Up

The objective of Project P0 is to produce a detailed RVSM Programme Plan upon which States will give a firm commitment to the implementation of RVSM at an agreed date.

The Project contains the following summary activities:

• 0.1 Establishment of Programme Support Office
• 0.2 Development RVSM Master Plan
ii) Sub Programme  P1 - Airspace User Preparation & Performance Verification

The objectives of Sub Programme P1 will be to ensure that all Operators intending to fly in RVSM airspace are RVSM approved and to confirm the accuracy of their vertical navigation performance through the operation of a monitoring infrastructure.

The Sub Programme contains the following work packages:

- 1.1 Enabling Aircraft System Development
- 1.2 RVSM Approval Achievement
- 1.3 Monitoring Policy & System Architecture
- 1.4 Monitoring System Development
- 1.5 Monitoring Organisation Development
- 1.6 Operation of Monitoring System
- 1.7 Post RVSM Implementation Technical Enhancements

iii) Sub Programme  P2 - Air Traffic Management (ATM) Preparation

The objective of Sub Programme P2 is to ensure that all ATS provider units are well prepared and ready for the introduction of RVSM on the agreed date.

The Sub Programme contains the following work packages:

- 2.1 Airspace Issues
- 2.2 ATC Procedures
- 2.3 ATS Providers Support Team
- 2.4 ATC Training
- 2.5 Flight Planning - Integrated Initial Flight Plan Processing System (IFPS)
- 2.6 RVSM Impact on Air Traffic Flow Management (ATFM)
- 2.7 ATS System Modification
- 2.8 Military Aviation Preparation for RVSM
- 2.9 ATS Providers Countdown Schedule
- 2.10 Legal Issues
2.11 Operational Data Collection for Safety Assurance

2.12 Post RVSM Implementation Operational Enhancements

iv) Sub Programme P3 - RVSM Safety Assurance

The objective of Sub Programme P3 is to guarantee that Safety Assessments made prior to implementation, just after implementation, and at the end of the RVSM Programme will meet the agreed RVSM Safety Objectives.

The Sub Programme contains the following work packages:

3.1 Definition Phase

3.2 Safety Risk and Hazard Analysis (Safety Case Part 1)

3.3 Monitoring Risks and Hazards pre implementation (Safety Case Part 2)

3.4 Requirements for National Implementation (Safety Case Part 3)

3.5 Post Implementation Monitoring (Safety Case Part 4)

The following safety objectives of RVSM implementation are described in the RVSM safety policy document:

- The RVSM Programme has conducted a full Functional Hazard Analysis of the proposed operational concept. The analysis included, but was not restricted to, those risks already identified by ICAO for RVSM implementation;

- The RVSM Programme shall minimise the programme’s contribution to the risk bearing incidents or aircraft accidents as far as it is reasonably practicable to do so;

- The RVSM Programme has established an explicit Safety Assurance Project to ensure that programme’s contribution to risk of an aircraft accident is minimised in accordance with the primary safety objective;

- In accordance with ICAO Guidance Material, the management of vertical collision risks within RVSM airspace shall meet the Target Level of Safety of $5 \times 10^{-9}$ fatal accidents per flight hour;

*In accordance with ICAO Guidance Material, the risk of mid-air collision in the vertical dimension within RVSM airspace due to technical height-keeping performance shall meet a Target Level of Safety of $2.5 \times 10^{-9}$ fatal accidents per flight hour.*

*Note: The above safety objectives, which will be the subject of ongoing studies, have been developed in line with the EUROCONTROL EATMP Safety Policy on quantitative safety levels, the EATMP Safety Policy on As Low As Reasonably Practical (ALARP), and with ICAO guidance on vertical technical risk.*
v) Project P4 - Marketing, Communication And Programme Management

The objective of Project P4 is to ensure that all RVSM Stakeholders are kept fully aware of the RVSM programmes and that their activities are co-ordinated as set out in the approved RVSM Master Plan.

The Project contains the following summary activities:

- 4.1 Marketing & Communications

2.3.5 Key Dates of the Work Programme

a) The following key dates are set out in the approved RVSM Master Plan:

- April 1999 - Approval of the RVSM Master Plan.

- November 1999 - Regulatory Material prepared and adopted by all States of Registry of Aircraft intending to operate in the European RVSM airspace.

- May 2001 - Confirmation that technical height-keeping performance meets the MASPS requirements and that operations in the European RVSM airspace will satisfy the TLS.

- 24 January 2002 - Introduction of RVSM between FL 290 and FL 410 inclusive throughout the whole of the European RVSM airspace.

- December 2002 - Initial confirmation, based on actual performance data acquired in a 1000 ft VSM operational environment, that the TLS has been satisfied.

- December 2004 – Final confirmation, based on actual performance data acquired in a 1000 ft VSM operational environment, that the TLS has been satisfied.
3. AIRWORTHINESS

3.1 Introduction

This material has been prepared in conjunction with the Joint Aviation Authorities (JAA). It provides an overview of the development, and content, of JAA Temporary Guidance Leaflet (TGL) No. 6, Revision 1, which is the authoritative document of the ECAC Member States on all issues relating to the European MASPS and on the approval of aircraft and operators for flight in designated RVSM airspace.

3.2 Background

The initial MASPS, for the height-keeping accuracy necessary for RVSM operations, was established by the ICAO RGCSP. It was further refined by the NAT SPG by means of a group of technical specialists from State authorities, aircraft and avionics manufacturers, and airline and pilot associations. This group developed material which was then published by the Federal Aviation Administration (FAA) as FAA Document 91 - RVSM: Interim Guidance for Approval of Operators/Aircraft for RVSM Operations, and by the JAA as Information Leaflet No. 23 (I.L. No. 23). These documents detailed the airworthiness, continuing airworthiness, and operations programmes necessary to approve operators and aircraft for RVSM operations in the NAT RVSM airspace.

3.3 JAA TGL No. 6

JAA TGL No. 6 was published in July 1998. It superseded I.L. No. 23 and extended the area of applicability of the requirements to any region in which RVSM operations are introduced. Regional differences (e.g. ATC Procedures) will be addressed in separate Annexes to the main body of TGL No. 6 which will ultimately be re-issued as a JAA Acceptable Means of Compliance (AMC). The technical requirements detailed in the main body of TGL No. 6 were unchanged from those set out in I.L. No. 23. In October 1999, JAA released TGL No. 6, Revision 1, in which procedures specific to European and North Atlantic RVSM operations have been replaced by references to appropriate documentation.

3.3.2 TGL No. 6, Rev.1, provides detailed information on:

a) the RVSM approval process;
b) RVSM performance requirements;
c) aircraft system requirements;
d) airworthiness approval;
e) continued airworthiness (maintenance procedures); and
f) operational approval,

together with the following Appendices:

Appendix 1 - Explanation of W/δ
Appendix 2 - Altimetry System Error (ASE) Components
Appendix 3 - Establishing and Monitoring Static Source Errors
3.3.3 TGL No. 6, Rev.1, details the following minimum equipment fit for aircraft seeking airworthiness approval for RVSM operations:

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

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

- Equipment for measuring static pressure sensed by the static source, converting it to pressure altitude and displaying the pressure altitude to the flight crew;

- Equipment for providing a digitally coded signal corresponding to the displayed pressure altitude, for automatic altitude reporting purposes;

- Static source error correction (SSEC), if needed to meet the performance criteria; and

- Signals referenced to a pilot selected altitude for automatic control and alerting. These signals should be derived from an altitude measurement system meeting the criteria of this document [TGL No. 6, Rev.1], and, in all cases, enabling the criteria relating to Altitude Control Output and Altitude Alerting to be met.

b) One Secondary Surveillance Radar (SSR) transponder with an altitude reporting system that can be connected to the altitude measurement system in use for altitude keeping.

c) An altitude alerting system.

d) An automatic altitude control system.
4. STATE APPROVAL OF AIRCRAFT FOR RVSM OPERATIONS

4.1 The State Approval Process

4.1.1 With effect from the agreed date of the implementation of RVSM in European airspace, Operators intending to conduct flights within the notified RVSM airspace shall require an RVSM Approval from the appropriate authority of the State in which the Operator is based, or of the State in which the aircraft is registered. Whilst the primary responsibility for gaining the necessary approval must rest with the Aircraft Operator, State aviation authorities will be expected to initiate such procedures as necessary to publicise the requirement for, and the means of obtaining, such approvals. In addition, State aviation authorities should maintain regular checks and records of the approvals which they have granted, and ensure that the relevant data is passed to the designated central data base (see paragraph 4.7).

4.2 RVSM Approval

4.2.1 An RVSM approval will encompass the following elements:

4.2.2 Airworthiness Criteria (including continuous airworthiness)

a) The European RVSM Airworthiness requirements are detailed in the JAA TGL No. 6, Rev.1. This provides guidance for the approval of newly built aircraft and for aircraft that are already in service. Aircraft may be granted an airworthiness approval against these requirements, or those of equivalent State documentation;

b) State Airworthiness authorities should also confirm that aircraft altimetry and height-keeping equipment will be maintained in accordance with approved procedures and servicing schedules as detailed in TGL No. 6, Rev.1; and

c) Whilst meeting the airworthiness requirements of an RVSM approval is, by itself, not sufficient to authorise flight in RVSM airspace, it will qualify the aircraft to enter the RVSM height monitoring programme. It is important therefore that the appropriate State Authority should advise the designated monitoring cell when the airworthiness criteria has been satisfied.

4.2.3 Operational Requirements

a) To meet the operational requirements of an RVSM approval, the operator will need to satisfy the responsible authority that they have introduced flight crew procedures for operations in the European RVSM airspace. The procedures should be based on the material set out in Parts 6 and 7 of this document.

4.3 Content of Operator RVSM Application

4.3.1 The required content of an Operator’s application for RVSM approval is detailed in TGL No. 6, Rev.1, and summarised below. The application should be submitted in sufficient time to permit evaluation before the intended start of RVSM operations and should include:

a) Airworthiness Documents - to show that the aircraft holds an RVSM airworthiness approval;

b) Description of Aircraft Equipment - appropriate to RVSM operations;
c) Training Programmes and Operating Practices and Procedures - holders of Air Operator’s Certificates (AOC) should submit training syllabi and other appropriate material to the responsible authority to show that the operating practices, procedures and training items related to RVSM operations are incorporated in initial, and where appropriate, recurrent training programmes. Other operators will need to comply with local procedures to satisfy the responsible authority that their knowledge of RVSM operating procedures and practices is equivalent to that set for AOC Holders, sufficient to hold approval to conduct RVSM operations. Guidance on the content of Flight Crew training programmes and operating practices and procedures is given in Part 6 of this document. The European RVSM ATC Procedures are set out in Part 7;

d) Operations Manuals and Checklists - the appropriate manuals and checklists should be revised to include information/guidance on standard operating procedures for RVSM operations;

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

f) Minimum Equipment List (MEL) - where applicable, an MEL, adapted from the Master Minimum Equipment List (MMEL) and relevant operational regulations, should include items pertinent to operating in RVSM airspace;

g) Maintenance - when application is made for operational approval, the operator should establish a maintenance programme acceptable to the responsible authority; and

h) Plan for participation in the Performance Verification/Monitoring Programmes - this plan will need to include, as a minimum, a check on a sample of the operators fleet by an independent height monitoring system.

4.3.2 The application of the RVSM approval process and the monitoring programmes may be sufficient to verify the height-keeping performance of an aircraft. However, the final step of the approval process may require a demonstration flight. The responsible authority may appoint an inspector for a flight in RVSM airspace to verify that all procedures are applied effectively. If the performance is satisfactory, the operator will be eligible for RVSM approval.

4.4 Issue of RVSM Approval

a) For AOC Holders - approvals will be issued by the appropriate authority in accordance with Joint Airworthiness Requirements (JAR OPS 1). Each aircraft group for which the operator is granted approval will be listed in the RVSM Approval.

b) For Non AOC Holders - these operators will be issued with an RVSM Approval as required by national regulations or with JAR OPS 2 when this is published. These approvals will be valid for a period specified in National Regulations, typically 2 years, and may require renewal.
4.5 Suspension or Revocation of Approval for RVSM Operations

4.5.1 The incidence of height-keeping errors that can be tolerated in an RVSM environment is small. Thus Operators will be expected to take immediate action to rectify the conditions which cause an error. The operator should report an occurrence involving poor height-keeping to the responsible authority within 72 hours. The report should include an initial analysis of causal factors and measures taken to prevent any reoccurrence. The need for follow up reports will be determined by the responsible authority.

4.5.2 Occurrences that should be reported and investigated are height-keeping errors which display:

   a) TVE equal to or greater than 300 ft (90 m)
   b) ASE equal to or greater than 245 ft (75 m)
   c) AAD equal to or greater than 300 ft (90 m)

4.5.3 An Operator that consistently experiences height-keeping errors, whether they are due to technical or operational causes, will have approval for RVSM operations revoked. If a problem is related to one specific aircraft type, then RVSM operational approval may be suspended or revoked for that specific type within the Operator’s fleet. If an Operator’s response to a notification of a height-keeping error is not timely or effective, then the relevant authority may consider suspending or revoking RVSM approval.

4.6 Provision for the Monitoring of Aircraft

4.6.1 A programme to monitor or verify aircraft height-keeping performance is considered a required element of European RVSM implementation. Verification and monitoring programmes have the basic objective of observing and evaluating the height-keeping performance of MASPS equipped aircraft to:

   a) confirm the efficacy of the RVSM MASPS;
   b) monitor the effectiveness of the approval process; and
   c) confirm that required safety levels will be achieved when RVSM is implemented.

Further information on monitoring is provided in Part 10.

4.7 Database of State Approvals

4.7.1 State aviation authorities will be expected to maintain a State Data Base (SDB) of all approvals which they have granted for operations in RVSM airspace. The details of the compilation and formatting of the data and the system operating parameters are under development.

4.7.2 The sharing of data between SDBs will greatly facilitate the tactical monitoring of the approval status of those aircraft which have flight planned to operate in RVSM airspace, should such monitoring be considered necessary.
5. FLIGHT PLANNING

5.1 Introduction

5.1.1 The application of a 300 m (1000 ft) vertical separation minimum between FL 290 and FL 410 inclusive in the European RVSM airspace necessitates changes to flight planning, as described in this section.

5.2 European RVSM airspace - Area of Applicability

5.2.1 RVSM shall be applicable in that volume of airspace between FL 290 and FL 410 inclusive in the following Flight Information Regions (FIRs)/Upper Information Regions (UIRs):


5.2.2 RVSM shall also be applicable in either all, or part of, that volume of airspace between FL 290 and FL 410 inclusive in the following FIRs/UIRs:

Canaries (AFI Region), Casablanca, Simeropol, Odessa, Lvov, Tunis.

Note: The volume of airspace specified in paragraphs 5.2.1 and 5.2.2 will be referred to as "EUR RVSM airspace".

5.3 Flight Rules

5.3.1 Flights shall be conducted in accordance with the Instrument Flight Rules (IFR) when operated within or above the EUR RVSM airspace.

5.4 General Changes - EUR Region

5.4.1 In addition to military operations, operators of customs or police aircraft should insert the letter “M” in Item 8 of the ICAO flight plan form. Operators of customs or police aircraft should refer to relevant Aeronautical Information Publications (AIPs) with regards to the flight planning requirements for Item 8 of the ICAO flight plan form.

5.4.2 All operators filing Repetitive Flight Plans (RPLs) shall include in Item Q of the RPL all equipment and capability information in conformity with Item 10 of the ICAO flight plan form.

5.5 RVSM Approved Aircraft

5.5.1 Operators of RVSM approved aircraft shall indicate the approval status by inserting the letter "W" in Item 10 of the ICAO flight plan form, regardless of the requested flight level.

5.5.2 Operators of RVSM approved aircraft shall also include the letter "W" in Item Q of the RPL, regardless of the requested flight level. If a change of aircraft operated in accordance with a repetitive flight plan results in a modification of the RVSM approval status as stated in Item Q, a modification message (CHG) shall be submitted by the operator.
5.5.3 Operators of RVSM approved aircraft intending to operate within the EUR RVSM airspace shall include the following in Item 15 of the ICAO flight plan form:

a) the entry point at the lateral limits of the EUR RVSM airspace and the requested flight level for that portion of the route commencing immediately after the RVSM entry point; and

b) the exit point at the lateral limits of the EUR RVSM airspace and the requested flight level for that portion of the route commencing immediately after the RVSM exit point.

5.6 Non-RVSM Approved State Aircraft

5.6.1 Operators of non-RVSM approved State aircraft with a requested flight level of FL 290 or above shall insert “STS/NONRVSM” in Item 18 of the ICAO flight plan form.

5.6.2 Operators of non-RVSM approved State aircraft intending to operate within the EUR RVSM airspace shall include the following in Item 15 of the ICAO flight plan form:

a) the entry point at the lateral limits of the EUR RVSM airspace and the requested flight level for that portion of the route commencing immediately after the RVSM entry point; and

b) the exit point at the lateral limits of the EUR RVSM airspace and the requested flight level for that portion of the route commencing immediately after the RVSM exit point.

5.7 Non-RVSM Approved Civil Aircraft

5.7.1 Except for State aircraft, operators of non-RVSM approved aircraft shall flight plan to operate outside of the EUR RVSM airspace.

5.7.2 Operators of non-RVSM approved aircraft shall include the following in Item 15 of the ICAO flight plan form:

a) if the departure aerodrome is outside of the lateral limits of the EUR RVSM airspace and the destination aerodrome is within the lateral limits of the EUR RVSM airspace:

   i) the entry point at the lateral limits of the EUR RVSM airspace; and

   ii) a requested flight level below FL 290 for that portion of the route commencing immediately after the entry point.

b) if both the departure and destination aerodromes are within the lateral limits of the EUR RVSM airspace, a requested flight level below FL 290;

c) if the departure aerodrome is within the lateral limits of the EUR RVSM airspace and the destination aerodrome is outside of the lateral limits of the EUR RVSM airspace:

   i) a requested flight level below FL 290 for that portion of the route within the lateral limits of the EUR RVSM airspace; and

   ii) the exit point at the lateral limits of the EUR RVSM airspace, and the requested flight level for that portion of the route commencing immediately after the exit point.

d) if both the departure and destination aerodromes are outside of the lateral limits of the EUR RVSM airspace, with a portion of the route within the lateral limits of the EUR RVSM airspace:
i) the entry point at the lateral limits of the EUR RVSM airspace, and a requested flight level below FL 290 or above FL 410 for that portion of the route commencing immediately after the entry point; and

ii) the exit point at the lateral limits of the EUR RVSM airspace, and the requested flight level for that portion of the route commencing immediately after the exit point.

5.8 Formation Flights

5.8.1 Except for State aircraft, operators of formation flights shall flight plan to operate outside of the EUR RVSM airspace. Except for State aircraft, formation flights shall not be issued an air traffic control clearance into the EUR RVSM airspace, regardless of their RVSM approval status.

5.8.2 Operators of formation flights of State aircraft shall not insert the letter “W” in Item 10 of the ICAO flight plan form, regardless of the RVSM approval status of the aircraft concerned. Operators of formation flights of State aircraft intending to operate within the EUR RVSM airspace as General Air Traffic (GAT) shall include “STS/NONRVSM” in Item 18 of the ICAO flight plan form.
6. FLIGHT CREW TRAINING PROGRAMMES, OPERATING PRACTICES AND PROCEDURES

6.1 Introduction

6.1.1 Flight crews will need to have an awareness of the criteria for operating in EUR RVSM airspace and be trained accordingly. The items detailed in paragraphs 6.2 to 6.6, together with the procedures and RTF phraseology set out in Part 9, should be standardised and incorporated into training programmes and operating practices and procedures. Certain items may already be adequately standardised in existing procedures. New technology may also remove the need for certain actions required of the flight crew. If this is so, then the intent of this guidance can be considered to be met.

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

6.2 Flight Planning

6.2.1 During flight planning the flight crew should pay particular attention to conditions that may affect operation in the EUR RVSM airspace (Part 5 refers). These include, but may not be limited to:

- verifying that the airframe is approved for RVSM operations;
- reported and forecast weather on the route of flight;
- minimum equipment requirements pertaining to height-keeping and alerting systems; and
- any airframe or operating restriction related to RVSM approval.

6.3 Pre-flight Procedures at the Aircraft for Each Flight

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

- review technical logs and forms to determine the condition of equipment required for flight in the EUR RVSM airspace, and ensure that maintenance action has been taken to correct defects to required equipment;
- during the external inspection of aircraft, particular attention should be paid to the condition of static sources and the condition of the fuselage skin near each static source and any other component that affects altimetry system accuracy. This check may be accomplished by a qualified and authorised person other than the pilot (e.g. a flight engineer or ground engineer);
- before take-off, the aircraft altimeters should be set to the QNH of the airfield and should display a known altitude, within the limits specified in the aircraft operating manuals. The two primary altimeters should also agree within limits specified by the aircraft operating manual. An alternative procedure using QFE may also be used. Any required functioning checks of altitude indicating systems should be performed.

Note: The maximum value for these checks cited in operating manuals should not exceed 23 m (75 ft).
• before take-off, equipment required for flight in EUR RVSM airspace should be operative, and any indications of malfunction should be resolved.

6.4 Procedures prior to EUR RVSM airspace entry

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

• Two primary altitude measurement systems.

• One automatic altitude-control system.

• One altitude-alerting device.

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

• Operating Transponder. An operating transponder may not be required for entry into all designated RVSM airspace. The operator should determine the requirement for an operational transponder in each RVSM area where operations are intended.

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

6.5 In-Flight Procedures

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

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

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

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

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

Note: It is recommended that the acquisition of the Cleared Flight Level (CFL) be accomplished using the altitude capture feature of the automatic altitude-control system, if installed.

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

- Ensure that the altitude-alerting system is operative;

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

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

- In normal operations, the altimetry system being used to control the aircraft should be selected for the input to the altitude reporting transponder transmitting information to ATC;

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

6.5.2 Contingency procedures after entering RVSM airspace are:

a) the pilot should notify ATC of contingencies (equipment failures, weather) which affect the ability to maintain the cleared flight level, and co-ordinate an appropriate plan of action. ATC Procedures relevant to such contingencies in the European RVSM airspace are detailed in Part 8.

b) examples of equipment failures which should lead to notification to ATC:

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

ii) loss of redundancy of altimetry systems;

iii) loss of thrust on an engine necessitating descent; or

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

c) the pilot should notify ATC when encountering severe turbulence.

6.6 Post Flight

6.6.1 In making technical log entries against malfunctions in height-keeping systems, the pilot should provide sufficient detail to enable maintenance to effectively troubleshoot and repair the system. The pilot should detail the actual defect and the crew action taken to try to isolate and rectify the fault.
6.6.2 The following information should be recorded when appropriate:

- Primary and standby altimeter readings.
- Altitude selector setting.
- Sub-scale setting on altimeter.
- Auto-pilot used to control the aeroplane and any differences when an alternative auto-
  pilot system was selected.
- Differences in altimeter readings, if alternate static ports selected.
- Use of air data computer selector for fault diagnosis procedure.
- The transponder selected to provide altitude information to ATC and any difference noted
  when an alternative transponder was selected.

6.7 Special Emphasis Items: Flight Crew Training

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

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

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

c) use and limitations, in terms of accuracy, of standby altimeters in contingencies. Where
   applicable, the pilot should review the application of static source error correction/position
   error correction through the use of correction cards;

   *Note: Such correction data will need to be readily available on the flight deck.*

d) problems of visual perception of other aircraft at 300 m (1000 ft) planned separation during
   darkness, when encountering local phenomena such as northern lights, for opposite and same
   direction traffic, and during turns;

e) characteristics of aircraft altitude capture systems which may lead to overshoots;

f) relationship between the aircraft's altimetry, automatic altitude control and transponder
   systems in normal and abnormal conditions; and

  g) any airframe operating restrictions, if required for the specific aircraft group, related to
     RVSM airworthiness approval.
7. **ATC PROCEDURES**

7.1 **Introduction**

7.1.1 The development of the ATC procedures required for the application of a 300 m (1000 ft) vertical separation minimum in the designated European airspace between FL 290 and FL 410 inclusive represents one pre-requisite for the safe application of ATC in the European RVSM airspace.

7.1.2 The ATM Procedures Development Sub-Group (APDSG) of the EUROCONTROL Airspace and Navigation Team (ANT) began the development of RVSM procedures in June 1996. Subsequent meetings of the APDSG have refined and updated the procedures as an ongoing process, culminating in the procedures described herein.

7.1.3 The ATC procedures have been developed taking into account the results of simulations sponsored by EUROCONTROL, including:

a) the second continental RVSM Simulation.

b) the RVSM Real-Time Simulation Study, Nieuw Milligen, The Netherlands.

c) the third continental RVSM Simulation

d) the RVSM Real-Time Simulation - Constanta, Romania

e) the fourth RVSM Real-time Simulation - Ankara, Turkey

f) the fifth RVSM Real-time Simulation - core area

g) the RVSM Real-time Simulation - Riga, Latvia

h) the sixth RVSM Real-time Simulation - Cyprus

7.1.4 The ATC procedures for operations within the EUR RVSM airspace are contained in the 'ATC Manual for a Reduced Vertical Separation Minimum (RVSM) in Europe'.

7.2 **Vertical Separation Minimum**

7.2.1 The ATC procedures are predicated on the requirement for air traffic control to provide vertical separation minimum within the EUR RVSM airspace, as follows:

a) 300 m (1000 ft) between RVSM approved aircraft;

b) 600 m (2000 ft) between:

i) non-RVSM approved State aircraft and any other aircraft operating within the EUR RVSM airspace;

ii) all formation flights of State aircraft and any other aircraft operating within the EUR RVSM airspace;

iii) non-RVSM approved aircraft and any other aircraft operating within the EUR RVSM transition airspace, as specified in paragraph 7.5.1, and within airspace designated in accordance with paragraph 7.4.1 for the European/North Atlantic interface; and
iv) an aircraft experiencing a communications failure in flight and any other aircraft, where both aircraft are operating within the EUR RVSM airspace.

7.3 EUR RVSM airspace interfaces

7.3.1 The EUR RVSM airspace interfaces with an RVSM environment to the west, the North Atlantic Region. Elsewhere, the EUR RVSM airspace interfaces with a non-RVSM environment. This is an important factor regarding the ATC procedures required for the transition of aircraft, in particular transition from an RVSM environment to a non-RVSM environment, and vice-versa.

7.4 European/North Atlantic (NAT) Interface

7.4.1 In order to enable non-RVSM approved aircraft operating to/from the NAT Region to be climbed/descended through the EUR RVSM airspace, State authorities responsible for the following FIRs may establish designated airspace within their FIRs for this purpose:

- Bodø (Domestic), Stavanger, Trondheim, Scottish, Shannon, London, Brest, Madrid, Lisboa.

7.4.2 ACCs/UACs providing air traffic control service within airspace designated in accordance with paragraph 7.4.1 may clear such non-RVSM approved aircraft to climb/descend through the EUR RVSM airspace.

7.4.3 Climbs/descents through RVSM airspace, in accordance with paragraph 7.4.2, shall be achieved before the aircraft passes the transfer of control point to the adjacent ACC/UAC, if applicable, unless otherwise specified in an inter-centre Letter of Agreement.

7.5 European RVSM transition airspace

7.5.1 Procedures for the transition of aircraft, including the accommodation of non-RVSM approved aircraft within the European RVSM airspace for the purpose of establishing aircraft at flight levels appropriate for the adjacent operating environment, shall be applicable in either all or part of the following FIRs/UIRs:


Note: The volume of airspace specified in paragraph 7.5.1 will be referred to as "EUR RVSM transition airspace".

7.6 ICAO Tables of Cruising Levels

7.6.1 Figure 7-1 illustrates the ICAO Tables of Cruising Levels (see Attachment A of this document). The table on page A-1 pertains to areas, such as the EUR RVSM airspace, where 300 m (1000 ft) vertical separation minimum is applied between FL 290 and FL 410 inclusive. The table on page A-2 pertains to other areas where 300 m (1000 ft) vertical separation minimum is not applicable between FL 290 and FL 410 inclusive.
7.7 ATC Clearances

7.7.1 Except for operations within the EUR RVSM transition airspace, as specified in paragraph 7.5.1, and within airspace designated in accordance with paragraph 7.4.1 (EUR/NAT interface), only RVSM approved aircraft and non-RVSM approved State aircraft shall be issued an air traffic control clearance into the EUR RVSM airspace.

7.7.2 Formation flights shall not be issued an ATC clearance into the EUR RVSM airspace, regardless of their RVSM approval status, except for formation flights of non-RVSM approved State aircraft. The applicable vertical separation minimum between formation flights of non-RVSM approved State aircraft and any other aircraft operating within the EUR RVSM airspace shall be 600 m (2000 ft).

7.8 State Aircraft Operating as Operational Air Traffic (OAT) within the EUR RVSM airspace

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

7.8.2 The vertical separation minimum required between State aircraft operating as OAT and any other aircraft operating as GAT, where both are operating within the EUR RVSM airspace, shall be 600 m (2000 ft).

7.8.3 However, in an airspace environment where both the civil and military ATC units are fully aware as to the RVSM approval status of all traffic involved, a reduced vertical separation minimum of 300 m (1000 ft) can be applied between an RVSM approved State aircraft operating as OAT, and RVSM approved GAT.

7.9 RVSM Approved and Non-RVSM Approved State Aircraft

7.9.1 Aircraft entering the EUR RVSM airspace from a non-RVSM environment shall be established at an "RVSM" flight level in accordance with the Tables of Cruising Levels, as published in ICAO Annex 2, Appendix 3, a), and/or in accordance with a Flight Level Allocation Scheme (FLAS) if applicable, and/or as specified in the inter-centre Letter of Agreement.
7.9.2 Any climb/descent clearances necessitated as a result of the requirement specified in paragraph 7.9.1 shall be initiated by the first ACC/UAC providing air traffic control service to the aircraft within the EUR RVSM airspace. Such flight level changes shall be achieved before the aircraft passes the transfer of control point to the adjacent ACC/UAC, unless otherwise specified in an inter-centre Letter of Agreement.

7.9.3 Aircraft exiting the EUR RVSM airspace to a non-RVSM environment shall be established with the applicable vertical separation minimum for the adjacent non-RVSM environment. Such aircraft shall also be established at a "non-RVSM" flight level, in accordance with the Tables of Cruising Levels, as published in ICAO Annex 2, Appendix 3, b), and/or in accordance with a Flight Level Allocation Scheme (FLAS) if applicable, and/or as specified in the inter-centre Letter of Agreement.

7.9.4 The applicable vertical separation minimum for the adjacent non-RVSM environment, and the "non-RVSM" flight level as specified in paragraph 7.9.3 shall be established by the last ACC/UAC providing air traffic control service to the aircraft within the EUR RVSM airspace. Both shall be achieved before the aircraft passes the transfer of control point to the adjacent ACC/UAC.

7.10 Non-RVSM Approved Aircraft

7.10.1 Except for State aircraft, non-RVSM approved aircraft operating from a departure aerodrome outside of the lateral limits of the EUR RVSM airspace with a destination aerodrome within the lateral limits of the EUR RVSM airspace shall be cleared to a flight level below FL 290.

7.10.2 Any descent clearances necessitated as a result of the requirement specified in paragraph 7.10.1 shall be initiated by the first ACC/UAC providing air traffic control service to the aircraft within the EUR RVSM airspace. Such flight level changes shall be achieved before the aircraft passes the transfer of control point to the adjacent ACC/UAC.

7.10.3 Except for State aircraft, non-RVSM approved aircraft operating from a departure aerodrome to a destination aerodrome which are both outside of the lateral limits of the EUR RVSM airspace, with a portion of the route within the lateral limits of the EUR RVSM airspace, shall be cleared to a flight level below FL 290 or above FL 410.

7.10.4 Any climb/descent clearances necessitated as a result of the requirement specified in paragraph 7.10.3 shall be initiated by the first ACC/UAC providing air traffic control service to the aircraft within the EUR RVSM airspace. Such flight level changes shall be achieved before the aircraft passes the transfer of control point to the adjacent ACC/UAC, in accordance with the Flight Level Allocation Scheme (FLAS), if applicable, and/or as specified in an inter-centre Letter of Agreement.

7.10.5 Additionally, such aircraft may subsequently be cleared to a flight level within, or through, the EUR RVSM airspace by the last ACC/UAC providing air traffic control service to the aircraft within the EUR RVSM airspace, provided that the level change will be achieved before the aircraft passes the transfer of control point to the adjacent ACC/UAC.

7.10.6 Except for State aircraft, non-RVSM approved aircraft operating from a departure aerodrome within the lateral limits of the EUR RVSM airspace to a destination aerodrome outside of the lateral limits of the EUR RVSM airspace shall be cleared to a flight level below FL 290.
7.10.7 Such aircraft may subsequently be cleared to FL 290 or above by the last ACC/UAC providing air traffic control service to the aircraft within the EUR RVSM airspace, provided that the level change will be achieved before the aircraft passes the transfer of control point to the adjacent ACC/UAC.

7.10.8 Except for State aircraft, non-RVSM approved aircraft operating from a departure aerodrome to a destination aerodrome which are both within the lateral limits of the EUR RVSM airspace shall be cleared to a flight level below FL 290.
8. **IN-FLIGHT CONTINGENCY PROCEDURES**

8.1 **Introduction**

8.1.1 This section contains procedures for in-flight contingencies that involve a loss of vertical navigation performance required for flight within the EUR RVSM airspace.

8.1.2 An in-flight contingency affecting flight in the EUR RVSM airspace pertains to unforeseen circumstances that directly impact the ability of one or more aircraft to operate in accordance with the vertical navigation performance requirements of the EUR RVSM airspace. For example, such in-flight contingencies can result from degradation of aircraft equipment associated with height-keeping, and from turbulent atmospheric conditions.

8.2 **General Procedures**

8.2.1 The pilot shall inform air traffic control as soon as possible of any circumstances where the vertical navigation performance requirements for the EUR RVSM airspace cannot be maintained. In such cases, the pilot shall obtain a revised air traffic control clearance prior to initiating any deviation from the cleared route and/or flight level, whenever possible. Where a revised air traffic control clearance could not be obtained prior to such a deviation, the pilot shall obtain a revised clearance as soon as possible thereafter.

8.2.2 Air traffic control shall render all possible assistance to a pilot experiencing an in-flight contingency. Subsequent air traffic control actions will be based on the intentions of the pilot, the over-all air traffic situation, and the real-time dynamics of the contingency.

8.3 **Degradation of Aircraft Equipment - Pilot Reported**

8.3.1 When informed by the pilot of an RVSM approved aircraft operating in the EUR RVSM airspace that the aircraft's equipment no longer meets the RVSM Minimum Aircraft System Performance Specification (MASPS), air traffic control shall consider the aircraft as non-RVSM approved.

8.3.2 Air traffic control shall take action immediately to provide a minimum vertical separation of 600 m (2,000 ft) or an appropriate horizontal separation from all other aircraft concerned operating in the EUR RVSM airspace. An aircraft rendered non-RVSM approved shall normally be cleared out of the EUR RVSM airspace by air traffic control, when it is possible to do so.

8.3.3 Pilots shall inform air traffic control, as soon as practicable, of any restoration of the proper functioning of equipment required to meet the RVSM MASPS.

8.3.4 The first ACC/UAC to become aware of a change in an aircraft's RVSM status shall coordinate with adjacent ACCs/UACs, as appropriate.

8.4 **Severe Turbulence - Not Forecast**

8.4.1 When an aircraft operating in the EUR RVSM airspace encounters severe turbulence due to weather or wake vortex that the pilot believes will impact the aircraft's capability to maintain its cleared flight level, the pilot shall inform ATC. Air traffic control shall establish either an appropriate horizontal separation or an increased minimum vertical separation.

8.4.2 Air traffic control shall, to the extent possible, accommodate pilot requests for flight level and/or route changes, and pass traffic information, as required.
8.4.3 Air traffic control shall solicit reports from other aircraft to determine whether RVSM should be suspended entirely or within a specific flight level band and/or area.

8.4.4 The ACC/UAC suspending RVSM shall co-ordinate any such suspension(s), and any required adjustments to sector capacities with adjacent ACCs/UACs, as appropriate, to ensure an orderly progression to the transfer of traffic.

8.5 Severe Turbulence - Forecast

8.5.1 Where a meteorological forecast is predicting severe turbulence within the EUR RVSM airspace, air traffic control shall determine whether RVSM should be suspended, and if so, the period of time, and specific flight level(s) and/or area.

8.5.2 In cases where RVSM will be suspended, the ACC/UAC suspending RVSM shall co-ordinate with adjacent ACCs/UACs with regards to the flight levels appropriate for the transfer of traffic, unless a contingency flight level allocation scheme has been determined by letter of agreement. The ACC/UAC suspending RVSM shall also co-ordinate applicable sector capacities with adjacent ACCs/UACs, as appropriate.
9. CONTROLLER/PILOT PHRASEOLOGY

9.1 Introduction

This section contains controller/pilot phraseology for operations within the EUR RVSM airspace.

<table>
<thead>
<tr>
<th>PURPOSE</th>
<th>PHRASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>For the controller to ascertain RVSM approval status of an aircraft.</td>
<td>CONFIRM RVSM APPROVED</td>
</tr>
<tr>
<td>For the pilot to report non-RVSM approval status:</td>
<td>NEGATIVE RVSM</td>
</tr>
<tr>
<td>• on the initial call on any frequency within the EUR RVSM airspace controller shall provide a read back with this same phrase; and</td>
<td></td>
</tr>
<tr>
<td>• in all requests for flight level changes pertaining to flight levels within the EUR RVSM airspace; and</td>
<td></td>
</tr>
<tr>
<td>• in all read backs to flight level clearances pertaining to flight levels within the EUR RVSM airspace.</td>
<td></td>
</tr>
<tr>
<td>Additionally, except for State aircraft, the pilot shall include this RTF phrase to read back flight level clearances involving the vertical transit through FL 290 or FL 410.</td>
<td></td>
</tr>
<tr>
<td>For the pilot to report RVSM approval status.</td>
<td>AFFIRM RVSM</td>
</tr>
<tr>
<td>For the pilot of a non-RVSM approved State aircraft to report non-RVSM approval status, in response to the RTF phrase: CONFIRM RVSM APPROVED.</td>
<td>NEGATIVE RVSM STATE AIRCRAFT</td>
</tr>
<tr>
<td>For the controller to deny an air traffic control clearance into the EUR RVSM airspace.</td>
<td>UNABLE CLEARANCE INTO RVSM AIRSPACE, MAINTAIN [or DESCEND TO, or CLIMB TO] FLIGHT LEVEL (number)</td>
</tr>
<tr>
<td>For the pilot to report when severe turbulence affects the aircraft's capability to maintain the height-keeping requirements for RVSM.</td>
<td>UNABLE RVSM DUE TURBULENCE</td>
</tr>
<tr>
<td>For the pilot to report that the aircraft's equipment has degraded below the MASPS required for flight within the EUR RVSM airspace. This phrase is to be used to convey both the initial indication of the non-MASPS compliance, and henceforth, on initial contact on all frequencies within the lateral limits of the EUR RVSM airspace until such time as the problem ceases to exist, or the aircraft has exited the EUR RVSM airspace.</td>
<td>UNABLE RVSM DUE EQUIPMENT</td>
</tr>
<tr>
<td>For the pilot to report the ability to resume operation within the EUR RVSM airspace after an equipment or weather-related contingency.</td>
<td>READY TO RESUME RVSM</td>
</tr>
<tr>
<td>For the controller to confirm that an aircraft has regained its RVSM approval status, or to confirm that the pilot is ready to resume RVSM operations.</td>
<td>REPORT ABLE TO RESUME RVSM</td>
</tr>
</tbody>
</table>
10. SYSTEM PERFORMANCE MONITORING

10.1 Introduction

10.1.1 This Part provides guidance on the monitoring of operations in European RVSM airspace. The objectives of the monitoring programme are to confirm that Safety Objectives (set out in paragraph 2.3.4 (iv)) are met and to assess the compliance of aircraft with the global height-keeping performance specification (paragraph 2.2 refers). This information will be taken into account by decision makers in judging whether overall safety goals applicable to the European RVSM airspace are being achieved.

10.1.2 One of the safety objectives for the European RVSM airspace (see paragraph 2.3.4) is that the TLS of $5 \times 10^{-9}$ fatal accidents per flight hour (representing the risk due solely to the loss of vertical separation from any cause) is not exceeded. The agreed method of assessing actual collision risk is by the use of a variant of the Reich collision risk model (CRM) suitable to the area.

10.1.3 The height-keeping errors which will contribute to collision risk in the European RVSM airspace can be divided into two categories: technical errors and operational errors. Technical errors, i.e. Altimetry System Errors (ASE) are caused by inaccuracies in the height-keeping equipment of aircraft, whereas, operational errors, i.e. Assigned Altitude Deviations (AAD) are caused by mistakes, by ATC or Flight Crew, which result in aircraft being flown at incorrect flight levels. ASE and AAD are the main constituents of Total Vertical Error (TVE). As aircraft operations in the European Region are, for the larger part, conducted under tactical radar control together with some procedural separation, the frequency of occurrence, size and duration of operational errors can be greatly reduced. Nevertheless, operational errors can, and do, occur and may make a significant contribution to the overall collision risk. The safety objectives take account of the risk from both technical errors and operational errors.

10.1.4 In order to ensure that the TLS is not being exceeded, it is necessary to monitor both the occurrence of vertical errors and the CRM parameter values on a continuing basis. Many of the parameter values used in the CRM are based on a planning horizon of approximately 10 years and require periodic monitoring.

10.1.5 The CRM parameters fall into two groups from the standpoint of monitoring requirements. The first group consists of two important parameters which are critical for safety assessment, in the sense that the actual risk in the airspace changes in proportion to changes in their values. The first of these parameters is an estimate of the proportion of flight time spent by aircraft, nominally separated by 1000 ft, in vertical overlap. This parameter is a function of the height-keeping performance of the overall aircraft population. It is termed the "vertical overlap probability" and denoted by the term “Pz(1000)”. The second of these parameters is an estimate of the number of aircraft passing events per aircraft flight hour.

10.1.6 The second group of CRM parameters is less demanding either because the CRM is relatively insensitive to their values, or because they are not expected to change substantially over the planning horizon of this document. They should be re-assessed periodically to ensure that their values reflect the current European RVSM airspace system.

10.1.7 It must be emphasised that the monitoring requirements, in particular the measurement of TVE, have been established at a stringent level appropriate to the first application of RVSM in a complex, high density continental airspace. As a result of initial work done in the NAT, and the additional data and operational experience which will be gained in Europe, it may be possible in the future to relax some of the monitoring requirements in the European Region and in other regions where the RVSM is introduced as a part of the global implementation process.
10.1.8 All of the measures which combine to constitute, or to verify, the height-keeping performance of an aircraft play a part in the concept of monitoring which is expected to make a significant contribution to risk reduction. The measures include:

- the requirement for aircraft to carry and use the equipment defined in the MASPS;
- the initial installation procedures, tests and, where necessary, flight checks of aircraft altimetry equipment;
- the compliance with State RVSM approval procedures;
- the compliance with continued airworthiness requirements;
- the adherence to ATC procedures; and
- the completion of in-flight operating drills by crews.

10.1.9 All of the foregoing measures are addressed in the relevant parts of this guidance material. However, these measures do not give a direct indication that the overall criterion for safety is met. This can be achieved only through independent system performance monitoring.

10.2 The Collision Risk Model

10.2.1 The risk of a mid-air collision due to a loss of vertical separation, from any cause, will be estimated using a CRM which has been adapted to meet the specific requirements of European airspace. The model brings together factors of the operational system, through probabilistic and deterministic elements, to produce an estimate of the long-term average system risk of aircraft collision.

10.3 Monitoring the Parameters of the CRM specification

10.3.1 Monitoring \( P_z(1000) \)

i) Monitoring of Height-keeping Performance.

\[
\text{The TLS associated with technical height-keeping performance, i.e. } 2.5 \times 10^{-9} \text{ fatal accidents per flight hour requires that an assessment of total system vertical overlap probability (} P_z(1000) \text{) be performed. This requires that the duration of all large errors in the vertical plane be reported and assessed. Thus, in addition to errors detected through the height monitoring system, all operational errors which occur in European RVSM airspace and which result in aircraft flying at or close to a flight level other than the one to which they were assigned, or were assigned to in error, must be reported.}
\]

ii) The contribution of operational errors to the overall risk could be high in the European Region. However, because the majority of aircraft in the region are controlled tactically using radar surveillance, it is anticipated that controller intervention will limit or reduce the size and duration of operational errors. Nonetheless, it is vital that reports of all operational errors should be sent by provider States to the designated monitoring agency.

iii) System risk is directly proportional to the total amount of flight time spent by aircraft at an incorrect flight level. The estimates of such times will be one of the key elements to be used in determining whether or not the system is in compliance with the TLS, using appropriate mathematical and statistical methods.
iv) Data sources for estimating time spent by aircraft at incorrect flight levels will include reports to the designated monitoring agency by ATC Authorities and Operators, as well as the results of special data gathering exercises using HMUs and other suitable systems.

b) Monitoring of Compliance with the Global System Performance Specification

i) The monitoring process will also be used to ensure that the fleet of aircraft flying in the European RVSM airspace meets the global system performance specification from which the RVSM MASPS was derived (paragraph 2.2.4 also refers).

ii) Because the global system performance specification, and in particular the Pz(1000) of $1.7 \times 10^{-8}$, was used to derive aircraft height-keeping performance specification (the MASPS), only errors resulting from incorrectly operating equipment are included in this aspect of the monitoring programme.

iii) An assessment of TVE is critical to an assessment of Pz(1000). As a result, the accuracy with which TVE can be measured is an important concern. TVE can be measured by comparing the geometric height of an aircraft, as measured by an HMU or GMU, to the geometric height of its assigned flight level. The accuracy of the measurement should be such that the mean error is 0 ft and the standard deviation (SD) of the error does not exceed 50 ft.

iv) These measured TVE data are fundamental to the monitoring process. Large amounts of such TVE data are needed to draw inference from the monitoring process with a high level of confidence.

v) Given a measured TVE and a simultaneous difference between automatically reported Mode C altitude and assigned flight level (i.e. the AAD), it is possible to estimate the aircraft’s ASE, i.e., the difference between its TVE and AAD. Thus it is important to obtain as much measured TVE data as possible, in order to calculate typical ASE values for airframes and for aircraft types, before and during initial applications of the RVSM, to determine whether these ASE values are constant and repeatable. If this can be shown it will become possible to estimate an aircraft’s TVE from a knowledge of the Mode C (or Mode S or Automatic Dependent Surveillance (ADS)) altitude.

10.3.2 Monitoring aircraft passing events involving plan overlap

a) In addition to an upper bound for Pz(1000), the original form of the global system performance specification provided upper bounds for aircraft passing frequency and the probability of lateral overlap. These values were derived for opposite direction traffic.

b) However, because the majority of traffic in European RVSM airspace will fly on crossing routes and because a growing proportion of traffic is expected to be flying direct routes in the future, the global system performance specification has been reformulated in terms of passing events involving plan overlap.

c) The aircraft passing frequency involving plan overlap in the European Region will be assessed on a monthly basis by the designated monitoring agency using traffic data supplied by the ATC authorities and/or the monitoring infrastructure.
10.3.3 Monitoring other CRM parameters

The remaining CRM parameters are average aircraft speed, relative speed between aircraft, and the average length, width and height of the aircraft operating in the European airspace. As stated previously, the risk of a mid-air collision is either relatively insensitive to these parameter values, or the values are not expected to change substantially over the planning horizon of this document. Intensive monitoring of the values of these parameters should not be necessary. The designated monitoring agency should be aware of the relative importance of these parameters in the overall process of ensuring that system safety is maintained, and should assess their likely values, on a periodic basis, using whatever means are deemed appropriate.

10.4 Assessment of the Safety of European RVSM Operations

10.4.1 The airspace parameters which are derived from the monitoring procedures outlined above allow the collision risk, in the vertical plane, in the airspace system to be assessed against the TLS. The height-keeping performance of aircraft can also be assessed and compared to the requirements of the global height-keeping performance specification outlined in paragraph 2.2.3 of this document.

10.4.2 Prior to implementation of EUR RVSM, mathematical and statistical techniques will be used to provide detailed information on the forecast performance of the system in terms of collision risk and aircraft height-keeping performance. After implementation of RVSM, the monitoring of the CRM parameters and the assessment of the system performance will continue so that any adverse trends may be quickly identified and corrected.

10.4.3 During the Monitoring Programme, the periodic reports will be issued to provide an analysis of the information obtained from routine monitoring procedures (HMU and GMU), mandatory occurrence reports, air-miss data, near mid-air collision reports or any other similar source of information on aircraft height-keeping performance. The appropriate European body should take action as necessary to ensure that the level of collision risk is maintained below the TLS.

10.5 Responsibilities of the Designated Monitoring Agency

10.5.1 For EUR RVSM, EUROCONTROL will act as the Regional Monitoring Agency, and, as such, will be responsible for the efficient and effective performance of the above monitoring tasks. To this end it will be necessary to:

- ensure the availability of all data required for the monitoring system;
- ensure the availability of monitoring system output;
- process the monitoring system output;
- take follow-up action after the detection of large height deviations;
- perform safety assessment;
- make recommendations to improve height-keeping performance; and
- issue periodic reports.
10.6 Objectives of the Height Monitoring System

10.6.1 In order to recommend an optimum monitoring system, it was necessary first to define overall monitoring targets. Following a review of information and data collected in the vertical studies programme and the monitoring activities in the NAT Region, it was assumed that ASE for individual airframes would be stable for a period of two years. Two important objectives of the Performance Verification aspects were therefore to establish the ASE performance of the airframes which will operate within the EUR RVSM airspace, and to confirm the assumptions concerning the stability of ASE.

10.6.2 On the basis of the above assumption, it was possible to establish the objectives of the monitoring programme and to consider how these objectives could be met. The ultimate objective was to carry out a complete census of airframes. The monitoring system should therefore be designed to be capable, in principle, of performing such a census over a period of one year. Because a complete census may prove to be an impractical target during the performance verification programme, the minimum targets, listed below, were agreed. These should enable the monitoring cell to collect sufficient information on the height-keeping performance of aircraft operating in the European Region, as follows:

a) Monitoring targets in the performance verification phase for aircraft falling into groups¹

- An initial minimum target of 60%* of the RVSM approved airframes of each aircraft group from each operator is required in order to generate sufficient monitoring data to confirm (with a high level of confidence) whether a particular group is compliant with the MASPS.

*Note: Based upon the analysis undertaken by the NAT RVSM Programme, this percentage may be reduced (to a minimum of 10% or 2 aircraft whichever is greater) once a sufficient number of aircraft have been monitored. The lower limit can be applied once sufficient data has been acquired to demonstrate that the group as a whole can meet the MASPS with a high level of confidence.

b) Monitoring targets in the performance verification phase for aircraft not falling into groups:

- All non-group RVSM approved aircraft need to be monitored on an individual basis unless flight test evidence can be provided to show that each airframe is compliant with the MASPS.

c) Use of NAT experience - On the assumption that ASE is demonstrated to be stable, it is proposed to use data from the NAT monitoring programme as follows:

- If an operator is, or has been, participating in the NAT monitoring programme, the number of aircraft of that operator monitored in the NAT programme will be used in determining how many aircraft of that operator should be monitored in the European RVSM monitoring programme;

1 Group aircraft are those of nominally identical design and build with respect to all details that could influence the accuracy of height keeping performance. A detailed explanation is given in JAA TGL No.6 Para 9.3.1.
d) Target of Monitoring Prior to RVSM Implementation - Subject to a satisfactory collision risk assessment and other operational considerations, the introduction of RVSM could be made provided that 90% of the flights in the area of interest would be made by operator-aircraft group pairings or non-group aircraft that have satisfied the monitoring requirements during the verification programme.

10.6.3 These targets are considered to be the minimum necessary to ensure that a representative sample of MASPS approved aircraft will be obtained. The data obtained from a monitoring programme that meets these targets will be sufficient to provide:

a) further evidence of the stability of ASE;

b) guidance on the efficacy of the MASPS and on the effectiveness of altimetry system modifications; and

c) confidence that the TLS will be met.

10.6.4 It is important to note that these minimum targets have been agreed on the assumption that the observed aircraft height-keeping performance would meet the global requirements and consequently that the collision risk due to technical errors would satisfy the technical TLS of $2.5 \times 10^{-9}$. If the observed performance proved to be significantly worse than the global height-keeping requirements, then the minimum sampling requirements might have to be increased to determine both the cause of the errors and whether or not the TLS would be threatened.

10.7 Description of the Height Monitoring System

10.7.1 Currently there are two accepted methods of measuring aircraft height-keeping performance. These are:

a) Height Monitoring Unit (HMU). This is a fixed ground based system which employs a network of a Master and 4 Slave Stations to receive aircraft SSR Mode A/C signals to establish the three dimensional position of the aircraft. The geometric height of the aircraft is measured to an accuracy of 30 ft (1 Standard Deviation (SD)). This is compared, in near real time, with meteorological input data on the geometric height of the assigned Flight (Pressure) Level to obtain a measurement of the Total Vertical Error (TVE) of the target aircraft. The aircraft SSR Mode C data is also recorded to determine the extent of any Assigned Altitude Deviation (AAD) and for subsequent aircraft identification, when the SSR Mode S response is not available.

b) GPS Monitoring Unit (GMU). A GMU is a portable “box” (contained in a carry case approximately 51 x 35 x 20 cm) which contains a GPS receiver, a device for recording and storing the GPS three dimensional position data, and two separate GPS receiver antennas which need to be attached to aircraft windows using suction pads. The GMU is positioned on board the candidate aircraft and, being battery powered, functions independently of the aircraft systems. Following the flight the recorded GPS data are sent back to a central site where, using differential post processing, aircraft geometric height is determined. A network of not more than 25 GMUs will make up the GPS Monitoring System (GMS).

10.7.2 It is intended that the EUR Height Monitoring System should be a hybrid system of HMUs and GMUs which makes optimum use of the advantages offered by each. Thus the strategic and inflexible characteristics of the HMUs, which can provide a large and predictable rate of collection of high quality data at relatively high installation and low maintenance/ongoing operating costs, can be blended with the tactical flexibility of the GMU which permits the targeting of specific aircraft at a low initial purchase price, but with relatively high operating costs in both manpower and logistics. The resultant system will be capable of
acquiring a representative sample of the height-keeping performance of the aircraft population by operator, type or airframe, or if required, a complete census of RVSM approved aircraft.

10.7.3 Over a period of time the HMUs will provide repeat samples of the height-keeping performance of individual aircraft. These data will establish the typical ASE range for a variety of aircraft types and will be the basis of the studies to determine whether the assumptions regarding the stability and repeatability of ASE are valid.

10.7.4 Those aircraft which normally operate on routes which do not pass within the effective range of one of HMUs may be specifically selected for monitoring by the GMS. The GMS can also be used to obtain repeat measurements of airframes and aircraft types which have been shown to be poor performers. Those Operators selected for such monitoring by the GMS will be expected to co-operate fully.

10.7.5 A combination of HMUs and a GMS is expected to provide the most efficient means of achieving the verification and monitoring objectives. Furthermore, because of the complementary nature of the systems, both elements (HMU/GMS) are equally critical to the composition of the hybrid system.

10.7.6 The height monitoring system for EUR RVSM is planned to include three HMUs with a 45 NM radius coverage area, located near Nattenheim (Germany), Geneva (Switzerland) and Linz (Austria). The measurement data from the existing (NAT) HMU at Strumble (UK) will also be used in the EUR RVSM height monitoring programme. The GMS will consist of not more than 25 GMUs, together with GPS reference stations, post-flight processing facilities and adequate logistic support. The EUR RVSM monitoring programme will take due account of information available from RVSM monitoring programmes in other regions.

10.8 Monitoring Procedures

10.8.1 Detailed monitoring procedures have been published in relevant State Aeronautical Information Circulars (AICs).
ATTACHMENT A

ICAO Annex 2, Appendix 3: Tables of Cruising Levels

The cruising levels to be observed when so required by this Annex are as follows:

a) in areas where, on the basis of regional air navigation agreement and in accordance with conditions specified therein, a vertical separation minimum (VSM) of 300 m (1 000 ft) is applied between FL 290 and FL 410 inclusive;*

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*Except when, on the basis of regional air navigation agreements, a modified table of cruising levels based on a nominal vertical separation minimum of 300 m (1 000 ft) is prescribed for use, under specified conditions, by aircraft operating above FL 410 within designated portions of the airspace.

**Magnetic track, or in polar areas at latitudes higher than 70 degrees and within such extensions to those areas as may be prescribed by the appropriate ATS authorities, grid tracks as determined by a network of lines parallel to the Greenwich Meridian superimposed on a polar stereographic chart in which the direction towards the North Pole is employed as the Grid North.

***Except where, on the basis of regional air navigation agreements, from 090 to 269 degrees and from 270 to 089 degrees is prescribed to accommodate predominant traffic directions and appropriate transition procedures to be associated therewith are specified.

Note.— Guidance material relating to vertical separation is contained in the Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive (Doc 9574).
b) in other areas:

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