

INTERNATIONAL CIVIL AVIATION ORGANIZATION



RVSM/RNAV/RNP TF/3 MEETING REPORT

(NAIROBI, 22 – 23 APRIL 2004)

The RVSM/RNAV/RNP Task Force is a Task Force of the AFI Planning and Implementation Regional Group (APIRG).

Its Reports are therefore submitted to APIRG through the ATS/AIS/SAR Sub-Group for review and action.

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of ICAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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PART I - HISTORY OF THE MEETING

1. Introduction

1.1 The Third meeting of the RVSM/RNAV/RNP Task Force (RVSM/RNAV/RNP TF/3) was convened pursuant to AFI/7 RAN Meeting Recommendations 5/7, 5/17 and APIRG/13 Decision 13/58 by the International Civil Aviation Organization at the ICAO ESAF Office, Nairobi, from 22 to 23 April 2004.

1.2 The meeting was opened by Mr. Lot Mollel, Regional Director of the ICAO Eastern and Southern African Office. He emphasized the preliminary studies which have to be done prior to the implementation of the required procedures aimed at increasing or improving the capacity of a given airspace in order to satisfy the demand of ever growing air traffic. In that regard, the Regional Director emphasized the importance of the Third Meeting of the RVSM/RNAV/RNP Task Force being organized pursuant to APIRG/13 Decision 13/58. He recalled APIRG 14 Conclusion 14/21 relating to the development of an AFI RVSM strategy/action plan within specific target dates and wished the members a fruitful deliberation with a view to further enhance the safety of air navigation in the Region.

2. Officers and Secretariat

2.1 The meeting nominated Mr. Yami Girma of Ethiopia as its moderator.

2.2 Mr. Apolo Kharuga, Regional Officer, Air Traffic Management of the ICAO ESAF Office, acted as the Secretary of the meeting. He was assisted by Messrs. Marcel Munyakazi (RO/ATM), Vic Van Der Westhuizen (ICAO RVSM Consultant) and Brou Konan (RO/ATM, WACAF Office, Dakar).

3. Attendance

3.1 The meeting was attended by 32 participants from 12 States and 3 International Organizations namely IATA, IFALPA and IFATCA. The list of participants is given at **Appendix A** to this report.

4. Working Language

4.1 The meeting was conducted in the English language only.

5. Agenda

5.1 The following Agenda was adopted:

Agenda Item 1: Review and follow-up action of conclusions of the second meeting of RVSM/RNAV/RNP Task Force

Agenda Item 2: Review of RVSM Strategy/Action Plan

Agenda Item 3: Review of the outcome of RVSM Seminar

Agenda Item 4: Any Other Business

6. Conclusions

6.1 The Task Force recorded its actions in the form of Conclusions.

Summary of Conclusions

Number	Title
Conclusion 3/1:	Safety assessment That: AFI RMA commence safety assessment as soon as possible but not later than 1 June 2004 .
Conclusion 3/2:	Civil/military coordination That: In order to ensure the safe and coordinated implementation of RVSM in the AFI Region, States should ensure that the military aviation authorities are fully involved in the planning and implementation process.
Conclusion 3/3:	Nomination of a National RVSM programme manager That: States/service providers who have not done so, nominate, as soon as possible, but not later than 31 May 2004 , a National RVSM Programme Manager who will be responsible for ensuring that the proper mechanism are put in place for the safe implementation of the RVSM programme and will also act as the focal point or contact person.
Conclusion 3/4	Reporting of data for monitoring and/or carrying out safety assessment That: <ul style="list-style-type: none"> a) All States institute procedures for reporting of data, incidents and conditions necessary for performing the collision risk calculations prerequisite for RVSM implementation to the AFI monitoring agency. The data will include, but not necessarily be limited to: <ul style="list-style-type: none"> i) Height deviations of 300 ft or more. ii) Total number of IFR movements for each month.

Number	Title
	<ul style="list-style-type: none"> iii) The average time per movement spent in the level band FL 290 to FL 410. iv) ATC/ATC coordination failures. v) Turbulence; and vi) Traffic data. <ul style="list-style-type: none"> b) All States institute procedures for reporting to the AFI monitoring agency data, incidents and conditions necessary for performing the collision risk calculations prerequisite for RVSM implementation. c) AFI Regional monitoring agency should use the reporting format at Appendix B to this report.
Conclusion 3/5:	<p>Implementation of RVSM in the AFI Region</p> <p>That:</p> <ul style="list-style-type: none"> a) All RVSM implementation preparation works (safety, assessment, training) be done taking into consideration the FL band between 290 and 410 inclusive. b) The final decision for implementation be taken at the informal coordination meeting planned for September/October 2004 (TF/5 meeting) taking into account status of readiness of States and operators. c) Implementation of RVSM in the AFI Region be harmonized and coordinated with the implementation time frames of adjacent Regions.
Conclusion 3/6:	<p>Training of all personnel involved with the implementation of RVSM in the AFI Region</p> <p>That:</p> <ul style="list-style-type: none"> a) Seminars/Workshops be organized in the Region for training of air traffic services personnel in the RVSM field. b) States having difficulties in implementing RVSM implementation programme, may either individually or in group explore the possibility of seeking outside expertise. <p>ATS Training guidance material at Appendix C to this report be used by States for ATS Training on RVSM.</p>

Number	Title
Conclusion 3/7:	<p>Guidance material for Airworthiness and Operational Approval</p> <p>That:</p> <p>States in the AFI Region be urged to include in their national legislation and regulations the Airworthiness and Operational Approval process for aircraft and operators intending to operate within a designated RVSM airspace based on provisions of ICAO Annex 6 Part 1 Chapt 7 para. 7.2.3 and the guidance material contained in JAA Temporary Guidance Leaflet (TGL) N°6. (Appendix D refers).</p>
Conclusion 3/8:	<p>Enforcement in national legislation</p> <p>That :</p> <p>States which have not done so, take the appropriate measures in order:</p> <ul style="list-style-type: none"> a) to publish an AIC informing the users of their intention to implement RVSM. b) to include the necessary provisions in their national legislation (AIPs). c) for ICAO Regional Office concerned to circulate to States the Sample AIC, NOTAM and AIP Supplement on RVSM (Appendix E refers).
Conclusion 3/9:	<p>Amendment to ICAO Doc. 7030</p> <p>That:</p> <p>ICAO process as soon as possible but not later than 15 May 2004 an amendment proposal to the AFI SUPPs Doc.7030 at Appendix F to this report.</p>
Conclusion 3/10:	<p>Funding of the RVSM implementation programme</p> <p>That:</p> <p>National Governments, Regulatory bodies, operators, service providers and other stakeholders be granted budgetary allocations for acquisitions and other activities necessary for ensuring that all the requirements are met in a timely manner in order to safely implement RVSM in the AFI Region.</p>

Number	Title
Conclusion 3/11:	<p>AFI RVSM Action Plan</p> <p>That:</p> <p>The updated RVSM Action Plan at Appendix G be circulated to States for action.</p>
Conclusion 3/12:	<p>Aircraft/Operators readiness survey</p> <p>That:</p> <ul style="list-style-type: none"> a) ICAO carry out a survey on the reactions of non-IATA/AFRAA operators. b) The results of ICAO/IATA surveys be presented at the RVSM TF/4 meeting for consideration.
Conclusion 3/13:	<p>Monitoring of Height Deviations</p> <p>That:</p> <ul style="list-style-type: none"> a) ICAO request the States of Botswana, Cape Verde, Egypt, Ghana, Kenya, South Africa, Spain, Tanzania, Tunisia and Nigeria to establish at the ACC where radar is implemented, a unit to conduct monitoring of aircraft height deviations in the AFI RVSM airspace using the format at Appendix H to this report. b) The data collected at a) above be forwarded to AFI RMA for action.
Conclusion 3/14:	<p>AFI RVSM Documents</p> <p>That the documents at Appendix I be circulated to States for action.</p>
Conclusion 3/15:	<p>Organization of AFI airspace in respect of AFI RVSM airspace</p> <p>That the ATS/SG of APIRG consider as one of its tasks the issue of restructuring of the AFI Region airspace in light of the introduction of RVSM.</p>

PART II REPORT ON AGENDA ITEMS**Agenda Item 1: Review and follow-up action of conclusions of the second meeting of RVSM/RNAV/RNP Task Force**

1.1 Under this Agenda Item the meeting reviewed and noted the action taken on the conclusions of the second meeting of the RVSM/RNAV/RNP/Task Force. It reinstated those conclusions which were still in force and proposed the action to be taken before the Forth Task Force Meeting planned for June 2004. These conclusions including those formulated at RVSM/TF/3 appear at Part I of this report.

Agenda Item 2: Review of RVSM Strategy/Action Plan

2.1 The meeting recalled that in noting the APIRG/14 Conclusion 14/21 (implementation of RVSM in the AFI Region) the ANC had expressed its concern that RVSM required a sophisticated implementation process and requested the States to monitor preparations and assist to the extent possible as an acceptable level of safety should be achieved and maintained.

2.2 The meeting noted that the ANC emphasized the provision of ATC and the required airworthiness approach as a pre-requisite to the RVSM implementation.

2.3 It recalled that the RVSM TF/2 meeting had developed the strategy/action plan and reviewed relevant comments from States for Task Force Members and the interested international organizations. The comments thereby received have been incorporated in the new revised version of the strategy/action plan.

2.4 The meeting agreed that the implementation of RVSM in AFI should be pursued in a pragmatic manner and in detail following the steps in the revised strategy/action plan. The meeting agreed that the strategy/action plan will be reviewed on each of the several TF meetings scheduled for this quarter before any decision is made to implement the RVSM.

2.5 Furthermore, the meeting agreed that the revised AFI strategy/action plan at **Appendix G** and the documents relating to RVSM implementation at **Appendix I** be circulated to States for action.

In view of the foregoing, the following conclusions were formulated.

Conclusion 3/11 AFI RVSM Action Plan

That:

The updated RVSM Action Plan at Appendix G be circulated to States for action.

Conclusion 3/14 AFI RVSM Documents

That the documents at Appendix I be circulated to States for action.

Report on Agenda Item 3: Review of the outcome of RVSM Seminar

3.1 The Task Force considered the following topics which were covered by the seminar and incorporated them as appropriate in the AFI RVSM strategy/action plan and developed also relevant conclusions on these issues and included some material in the relevant RVSM documents for application in AFI region.

Subjects/Topics:**1. RVSM requirements:**

- 1.1 RVSM MASPS.
- 1.2 Guidance Material (OPS/AIR).
- 1.3 Crew requirements approvals.
- 1.4 Performance criteria.
- 1.5 Training.
- 1.6 Aircraft systems.

2. Air Traffic Management

- 2.1 Flight rules.
- 2.2 State aircraft.
- 2.3 Vertical Separation Minima.
- 2.4 Flight Planning.
- 2.5 RVSM Transition airspace.
- 2.6 In-flight control grounds.
- 2.7 Phraseologies.
- 2.8 COM failure procedures.
- 2.9 ATM options for RVSM.
- 2.10 Letters of Agreements.
- 2.11 Air Traffic System support.

3. Height monitoring

- 3.1 ICAO prerequisites.
- 3.2 Monitoring requirements.
- 3.3 HMUs and GMUs.
- 3.4 Role of RMAs.
- 3.5 State responsibilities and coordination with RMSs.

4. ATC and Pilot Training.**5. RVSM Safety Assurance.**

- 5.1 Overall safety requirements.
- 5.2 RVSM safety managements.
- 5.3 Stakeholders responsibilities.
- 5.4 ATM and safety objective.
- 5.5 RVSM safety policy.
- 5.6 Switch-over planning CVSM to RVSM.
- 5.7 Switch-over Risk Analysis.
- 5.8 ICAO RVSM TLS.

3.2 The Task Force revised the time scales in the action plan and identified the initial RVSM airspace. It considered further work needed to be done on airspace restructuring. Aircraft altimetry (avionics) in meters and feet was also considered.

3.3 Readiness of AFI RMA

3.3.1 It was noted that South Africa had established an RMA located at ATNS HQ in Johannesburg.

3.4 Amendment to Doc.7030

3.4.1 Draft amendment proposal to Doc.7030 relating to RVSM was provided to Task Force members and will be further refined by the secretariat for circulation in accordance with the ICAO established procedures.

3.5 Operation in RVSM airspace

3.5.1 Conclusions were drawn on the following issues and relevant material incorporated in the related RVSM documents:

- RVSM approved aircraft.
- Non-RVSM aircraft.
- State aircraft.
- Exemptions.

3.6 Determination of the ACC to conduct flight monitoring

3.6.1 The Task Force identified these ACCs and a conclusion was drawn in this respect.

3.7 Wake Turbulence

3.7.1 Wake Turbulence issues were addressed and incorporated in Doc.7030.

3.8 ICAO provisions on ACAS and RVSM

3.8.1 The Task Force addressed these issues in relation to enhancing air safety.

3.9 Transition airspaces and interface FIRs.

3.9.1 The Task Force addressed these issues and incorporated them in the RVSM relevant documents.

3.10 Radio communication failure

3.10.1 Radio communications failure procedures, flight planning and ATM system support were also addressed.

Agenda Item 4: Any other business - Nil.

LIST OF PARTICIPANTS/LISTE DES PARTICIPANTS

No.	STATE/ETAT	NAME/NOM	TITLE/TITRE DESIGNATION	ADDRESS
1.	Angola	MS. DULCE da C. C. CACHIMBOMBO MANUEL	Chef de Département	Aeroporto International C. C. R. – DNAV – P. O. Box 841 – Luanda – Angola Tel:244-2-351267/244-91207559 Fax:244-2-351267 E-mail:dulcecachimbombo@yahoo.com.br
2.	Angola	MS. BERNARDA da PAIVA HENRIQUE	Air Traffic Controller	Aeroporto International 4 de Fevereiro C. C. R – DNAV P. O. Box 841 Luanda – Angola Tel:244-2-351267 Fax:244-2-351267/244-92512061 E-mail:dinahenrique@hotmail.com
3.	Djibouti	MR. IBRAHIM MOUSSA FARAH	Chef de la Division Trafic Aérien	Aéroport International de Djibouti B. P. 204 Tel :253-340350 Fax :253-340723 E-mail :ibrahim_aiddj@yahoo.fr
4.	Djibouti	MR. SAAD E. SIGAD	Contrôleur de la Circulation Aérienne	Aéroport International de Djibouti B. P. 204 Tel :253-340350 Fax :253-340723 E-mail :dtt@intnet.dj
5.	Egypt	MR. MAHMOUD M. FAWZI	D. G. of ATC Training Centre, Cairo (NANSC)	Egypt National Air Navigation Services Company (NANSC) Egypt, Cairo, Airport Road Tel :202-585-4494/2567830 Fax :202-268-0627 E-mail :abody_fawzi@hotmail.com

No.	STATE/ETAT	NAME/NOM	TITLE/TITRE DESIGNATION	ADDRESS
6.	Egypt	Mr. Nasr Eldin Ali Mohamed Sayed	ATC Technical Officer	Egypt National Air Navigation Services Co. Egypt, Cairo Airport Road Cairo Air Navigation Centre (CANC) ATC Office Tel :202-265-7883 Fax :202-268-0627 E-mail :neam2002@hotmail.com
7.	Ethiopia	Mr. Girma Yami	Director, Air Operations and Nav aids Department	Ethiopian Civil Aviation Authority P.O. Box 978 ADDIS ABABA - Ethiopia Tel:251-1-631995 Fax:251-1-612533 E-mail :caa.airnav@telecom.net.et
8.	Ethiopia	Mr. Gulelat Assefa	Head of FIR Division	Ethiopian Civil Aviation Authority P.O. Box 978 - ADDIS ABABA - Ethiopia Tel:251-1-631995/631997 Fax :251-1-612533 E-mail :caa.airnav@telecom.net.et
9.	Ethiopia	Demissie Gizaw	Chief Flight Operation	Ethiopian Civil Aviation Authority P.O. Box 978 ADDIS ABABA - Ethiopia Tel:251-1-631995/610440 Fax:251-1-612533 E-mail :caa.fsafety@telecom.net.et
10.	Kenya	Mr. Henry Daniel Ochieng	Manager – ANS JKIA	Kenya Civil Aviation Authority P. O. Box 30163 – NAIROBI - Kenya Tel:254-20-824557/824002/16 Fax:254-20-824716/825333 E-mail:kcaa@insightkenya.com
11.	Kenya	Mr. Erastus M. Njogu	Chief Air Traffic Control Officer	Kenya Civil Aviation Authority P. O. Box 30163 – NAIROBI - Kenya Tel:254-20-824557 Fax:254-20-824716 E-mail:kcaa@insightkenya.com

No.	STATE/ETAT	NAME/NOM	TITLE/TITRE DESIGNATION	ADDRESS
12.	Kenya	Mr. Calleb O. Omemo	Acting Chief Aeronautical Information Officer	Kenya Civil Aviation Authority P. O. Box 30163 – NAIROBI - Kenya Tel:254-20-824557/824002/16 Mobile:0722-396163 E-mail:kcaa@insightkenya.com
13.	Kenya	Eng. Shadrack Wesechere	Senior Superintendent Engineer	Kenya Civil Aviation Authority P. O. Box 30163 – 00100 - NAIROBI - Kenya Tel:254-20-824-557 Fax:254-20-824716 E-mail:kcaa@insightkenya.com
14.	Madagascar	MR. JEAN-LOUIS ALAIN	Chargé de la Circulation Aérienne et Procédures, Espace Aérien	Aviation Civile de Madagascar (ACM) 13, Rue F. Kasanga - Tsimbazaza B. P. 4414 ANTANANARIVO 101 Madagascar Tel:261-20-22-22162 Fax :261-20-22-24726 E-mail :acm@acm.mg
15.	Nigeria	Mr. E. O. Onasanya	General Manager, Airspace Planning and Technical Evaluation	Nigerian Airspace Management Agency P.M.B 21084, Ikeja, Lagos Tel:234-1-7765590/234-8033074353 Fax:234-1-4931330 E-mail:eonasanya@nama-nig.com
16.	Nigeria	Mr. Lanre Ogunwede	Airspace Manager	Nigerian Airspace Management Agency P.M.B 0182, Abuja - Nigera Tel:234-9-8100060 Fax: 234-9-8100060
17.	Nigeria	Mr. Godwin Chinyere Anusonwu	Quality Assurance Manager	ATS – Kano ACC NAMA – Mallam Aminu Kano International Airport – Kano - Nigeria Tel:08044123719/064-633162 Fax:064-633162

No.	STATE/ETAT	NAME/NOM	TITLE/TITRE DESIGNATION	ADDRESS
18.	Senegal	Mr. Mamadou Dieng	Civil Aviation Inspector of ANACS	Dakar – Senegal B. P. 8184 – Aeroport L. S. Senghor Tel:221-820-5335 Fax:221-820-3967 E-mail:jengtapha@yahoo.fr
19.	Somalia (CACAS)	Mr. Humphrey K. Mwachoki	Air Traffic Control Officer	ICAO SOM/PROJECT - Nairobi Civil Aviation Caretaker Authority for Somalia (CACAS) P. O. Box 46294 00100 - Nairobi - Kenya Fax:254-20-522340 Tel:254-20-622785 E-mail: icaosom@africaonline.co.ke
20.	Somalia (CACAS)	Capt. Mohamed A. Weli	Personnel Licensing Officer	ICAO SOM/PROJECT - Nairobi Civil Aviation Caretaker Authority for Somalia (CACAS) - P. O. Box 46294 00100 - Nairobi - Kenya Fax:254-20-522340 Tel:254-2-622785 E-mail: captainnoeli@hotmail.com
21.	South Africa	Mr. Robert Edward Rands	Manager – Operational Planning Services	ATNS - Private Bag X15 Kempton Park, 1620 Republic of South Africa Fax: 27-11-392-3946 Tel:27-11-961-0208 E-mail :robr@atns.co.za
22.	South Africa	Mr. Jeffrey M. Matshoba	Operations Research Specialist	ATNS - Private Bag X15 Kempton Park, 1620 Republic of South Africa Fax: 27-11-392-3869 Tel:27-11-961-0208 E-mail:jeffm@atns.co.za
23.	South Africa	Mr. Hennie Marais	Manager – Compliance and Standards	Private Bag X1 Bonaero Park, 1622 Republic of South Africa Fax: 27-11-3901209 Tel:27-11-570-0454 E-mail :henniem@atns.co.za

No.	STATE/ETAT	NAME/NOM	TITLE/TITRE DESIGNATION	ADDRESS
24.	South Africa	Mr. Arthur Downes	Flight Operations Inspector	18 Friar Tock Rd. Robindale – Randburg 2194 – South Africa Tel:27-12-426-0230/826319875 Fax:27-12-3462009 E-mail:downesa@caa.co.za
25.	South Africa	Mr. Thato Ronnie Mothusi	Airworthiness Inspector	P. O. Box 4218 – Reeds – 0158 Tel:012-4260055 Fax:012-3466057 E-mail:mothusir@caa.co.za
26.	South Africa	Mr. Msithini Albert Velaphi	Senior Airworthiness Inspector	Ikhaya Lokundiza 281 Middle Street Nilu Muckleneuk – Pretoria – 0001 South Africa Tel:27-12-346-5566 Fax:27-12-346-1807 E-mail:MsithiniA@caa.co.za
27.	Zimbabwe	Mr. Patrick R. Munawa	Chief Flight Operations/Inspector	Civil Aviation Authority of Zimbabwe Private Bag 6002 - HARARE , Zimbabwe Tel:263-4-585101 Fax:263-4-585107 E-mail :p.munawa@caaz.co.zw
INTERNATIONAL ORGANIZATIONS				
29.	IATA	Mr. Meissa N'diaye	A. Director IATA - AFI	Operations and Infrastructure (AFI) IATA - P. O. Box 47979, 00100 NAIROBI - Kenya Fax: E-mail:nd'iayem@iata.org
30.	IFALPA	Capt. Garvin Mckellar	Captain (Aeroplanes)	84 Mount Rhodes Drive Hout Bay – 7806 – South Africa Tel :27-21-790-7293 Fax :27-21-790-7293 E-mail :gavin.mckellar@wam.co.za

No.	STATE/ETAT	NAME/NOM	TITLE/TITRE DESIGNATION	ADDRESS
31.	IFATCA (Kenya)	Ms. Keziah A. Ogutu	Representative	Kenya Air Traffic Controllers Association P. O. Box 56819 - 00200 Nairobi - Kenya Tel :254-20-722-386001 E-mail :kezogutu@hotmail.com
32.	IFATCA (Kenya)	Mrs. Flora Wakolo-Kitao	RVSM/TF Member	Kenya Air Traffic Controllers Association P. O. Box 93915 MOMBASA – Airport Kenya Tel :254-041-434020 Ext.2399 Fax :254-041-432069 E-mail :flora_kitao@yahoo.com
33.	Netherlands (NLR)	Mr. Geert Moek		National Aerospace Laboratory NLR Anthony Fokkerweg 2 Amsterdam - The Netherlands Tel :31205113464 Fax :31205113210
SECRETARIAT				
	ICAO - Nairobi	Mr. Lot Mollel	Regional Director	Eastern and Southern African Office (ESAF) P. O. Box 46294 00100 – Nairobi – Kenya Tel :254-2-622394/622395/622396 E-mail :Lot.Mollel@icao.unon.org E-mail :icao@icao.unon.org
	ICAO – Nairobi	Mr. Samuel Githaiga	Deputy Regional Director	Eastern and Southern African Office (ESAF) P. O. Box 46294 00100 – Nairobi – Kenya Tel :254-2-622397 E-mail.Samuel.Githaiga@icao.unon.org

No.	STATE/ETAT	NAME/NOM	TITLE/TITRE DESIGNATION	ADDRESS
	ICAO - Nairobi	Mr. Apolo Kharuga	Regional Officer, ATM Secretary of ATS/AIS/SAR/SG	Eastern and Southern African Office (ESAF) P. O. Box 46294 00100 – Nairobi – Kenya Tel :622372/622374 E-mail :Apolo.Kharuga@icao.unon.org
	ICAO - Dakar	Mr. BROU Konan	Regional Officer, ATM	Western and Central African Office Boite Postale 2356 – Dakar – Senegal Tel :221-839-9393 Fax :221-823-6926 E-mail :icoadkr@icao.sn E-mail :kbrou@icao.sn
	ICAO - Nairobi	Mr. Vic VanderWesthuizen	RVSM Consultant	Eastern and Southern African Office (ESAF) P. O. Box 46294 00100 – Nairobi – Kenya Tel :622378 E-mail :vanderwesv@msn.com
	ICAO – Nairobi	Mr. Marcel Munyakazi	Regional Officer, ATM	Eastern and Southern African Office (ESAF) P. O. Box 46294 00100 – Nairobi – Kenya Tel :622373 E-mail :Marcel.Munyakazi@icao.unon.org

AFI RMA Reporting Format

NAVIGATION DEVIATION INVESTIGATION FORM				
Type of Report: PILOT - Flight CONTROLLER - ATC Unit				
Date/Time (UTC):		Type of Deviation: VERTICAL Type (A to O) (*) LATERAL Type (A to G)		
Causes: WEATHER (See 2-G) OTHERS (Specify)				
Conflict Alert Systems:				
DETAILS OF AIRCRAFT				
		First Aircraft		Second Aircraft (for vertical)
Aircraft Identification:				
Name of Owner/Operator:				
Aircraft Type:				
Departure Point:				
Destination:				
Route Segment:				
Flight Level:		Cleared	Actual	Cleared Actual
Cleared Track:				
Extent of deviation - magnitude and direction: (NM for lateral; feet for vertical)				
Amount of time at incorrect Flight Level/Track:				
Position where deviation was observed: (BRG/DIST from fixed point or LAT/LONG)				
WAS ATC Clearance obtained: YES NO		<u>If ATC clearance NOT obtained</u>		
		WERE Contingency procedures followed: YES NO		
Action Taken by ATC/Pilot:				
Other comments:				

(*) See deviation classification

NAVIGATION DEVIATION INVESTIGATION FORM

- _ The ATCO/Pilot should fill as many items as possible.
- _ Complementary data can be attached.

- _ The notification of any deviation (vertical or lateral) has to be classified, when possible, according to the following types:

1.- For Large Height Deviations (vertical deviation)

A
B
C
D
E
F
G
H
I
J

2.- For lateral deviations

A
B
C
D
E
F
G

Note that there are data that have to be notified by the pilot.

Remarks:

- 1.
- 2.

<u>DEVIATIONS MONITORING REPORT</u>	
<u>AREA CONCERNED :</u>	
<u>ALTITUDE :</u> From FL 290 up TO FL 410 both included	
<u>ACC/AO :</u>	
<u>MONTH :</u>	<u>YEAR :</u>
<input type="checkbox"/> (Number) Deviation Report Form attached (including TCAS RA and Airproxes)	
<input type="checkbox"/> NO Deviations reported (mark with an X)	
<hr/>	
The ACC/AO Responsible	
Name :	
Phone/E-mail :	
<hr/>	
Send to	
E-mail :	
Fax :	

The activities undertaken by the AFI Regional Monitoring Agency (ARMA) are performed through the two components of the permanent structure:

- The ARMA Manager who will be responsible for performing the functions assigned by the Agency and maintaining permanent communication with the representatives of the ACC's of the AFI Region.

- A Secretariat to facilitate the technical, operative and administrative tasks required by the Agency in order to follow the ARMA Manager's guidelines.

3. SUBMISSION OF STATISTICAL AND EQUIPMENT DATA

3.1 States and Organizations concerned are requested to submit to the ARMA the necessary statistical data to assist in the timely completion of the safety analysis.

3.2 The Operators flying through the AFI Region corridor are requested to notify ARMA, in an independent stage of the state regulator authorities, the aircraft equipment certification on RVSM and RNP-5.

3.3 In order to arrange sufficient data for safety assessment and testing for the implementation of CNS/ATM systems, aircraft operators are requested to include all the navigation and communications system availability, including ADS and CPDLC capability, in the flight plans (box no.10).

3.4 The ACC's of the AFI Region and the aircraft operators are also requested to send to ARMA the "Navigational Deviation Investigation Form" at page 1 above.

4. AFI RMA COOPERATIVE REQUEST

Any other cooperation in whatever way which may be required by the ARMA will ensure that all those tasks commissioned to ARMA by the corresponding ICAO forum may be duly performed.

5. ADDITIONAL INFORMATION

The ARMA is located in South Africa and can be reached at the following E-mail address: afirma@atns.co.za

The RMA Manager, Mr Rob Rands, can also be contacted by telephone and Fax:
Tel: [27]-11-392 4895 Fax: [27]-11-392 3946

The AFI RVSM Program Office (ARPO) can be reached at the following E-mail address at: : vanderwv@icao.unon.org

The ARPO Manager, Mr Vic Van Der Westhuizen , can also be contacted by telephone and Fax: Tel:[254] (2) 622378 Fax[254] (2) 623028

An AFI RVM WEB page is: www.icao.int/esaf

ATS Training Guidance Material

AFI AIR TRAFFIC SERVICES REDUCED VERTICAL
SEPARATION MINIMA
COURSE OUTLINE (ICAO 59)

Version: Draft
Page 1/9

- Course Aim:** The course will equip participants with the knowledge, skills and attitudes required to provide air traffic services within the designated RVSM and transition airspaces in the AFI Region, after completion of a period of on-the-job-training as prescribed by the specific national authority.
- Delivery Method:** The training will be delivered by means of Theoretical lectures, Classroom exercises and Simulator exercises.
- Language:** The course will be delivered in the English language.
- Pre-requisite Learning:** Trainees should hold valid Area Procedural and/or Area Radar ratings.
- Who Should Attend the Course:**
- Managers of Air Traffic Service Units where Area control is provided for the designated AFI RVSM airspace and airspace adjoining RVSM airspace.
 - Supervisors of Air Traffic Service Units where Area control is provided for the designated AFI RVSM airspace and airspace adjoining RVSM airspace.
 - Air traffic controllers providing Area control for the designated AFI RVSM airspace and airspace adjoining RVSM airspace.
- Note:** The information contained in this course will be also of use to air traffic controllers not working in the Area Control Centres. Examples are Approach and Aerodrome controllers working in sectors adjoining the designated RVSM or RVSM Transition airspaces or where those controllers have to interact with the Area Control Centres providing the service in the designated RVSM or RVSM Transition airspaces. Such controllers should be regarded as the secondary target population for the training.
- Course Duration:** Five days, consisting of:
- Nine (9) periods of theory lectures and one period of theory assessment.
 - Twenty six (24) periods of practical, this includes one (1) assessment per delegate.
 - Two periods for course administration (course opening and closing and delegate arrival etc).
- Assessment criteria:** Trainees are required to successfully complete:
- A written assessment, by achieving seventy (70) percent or more.
 - A practical assessment, by achieving seventy (70) percent or more.

Trainees will be allowed a once off reassessment in each of the above-mentioned assessments provided that a score of at least fifty (50) percent is achieved during the first attempt. Reassessments must be completed during the normal duration of the course.

1. Historical Background of RVSM. (Duration: 1 Period)

This module will provide the trainees with an awareness of the historical development of RVSM in ICAO.

1.1 Topic: The Origins of 2000 feet above FL 290.

Objective: Trainees will be aware of the origins of 2000 feet above FL 290.

Content:

- 1947 PANS RAC Vertical Separation.
- Reason for formation of Vertical Separation Panel in June 1954.
- 1960 PANS RAC Vertical Separation.
- Disbandment of the Vertical Separation Panel.

1.2 Topic Development of RVSM in other Regions

1.3 Topic: The need for RVSM in Europe.

Objective: Trainees will be aware of the need for RVSM in Europe.

Content:

- Cost/benefit analysis.
- Benefits of RVSM.

1.4 RVSM in AFI Region.

1.4.1 Topic: Background of RVSM in AFI.

Objective: Trainees will be aware of the background to RVSM in AFI.

Content:

- Extension of RVSM in AFI Region.

1.4.2 Topic: The need for RVSM in AFI Region.

Objective: Trainees will be aware of the need for RVSM in AFI Region.

Content:

- Cost/benefit analysis.
- Benefits of RVSM.

1.4.3 Topic: The RVSM programme organisation in the AFI Region.

Objective: Trainees will be aware of programme organisation and structures for RVSM in AFI Region.

Content:

- AFI RVSM Strategy.
- Regional RVSM Structure.
- RMA.
- National RVSM Structure.

2. Aircraft Certification. (Duration: 1 Period)

This module will provide the trainees with an awareness of the requirements and processes involved with the certification and approval of aircraft to operate with the designated RVSM airspace in the AFI region.

2.1 Approval Procedure.

2.1.1 Topic: State Approval Process.

Objective: Trainees will be aware of the state approval process.

Content:

- Responsibilities of the aircraft operator.

2.1.2 Topic: RVSM Approval Application.

Objective: Trainees will be aware of the content of an operator's RVSM approval application.

Content:

- Approval requirements.
- Content of operator application.

2.1.3 Topic: Issue of RVSM Approval

Objective: Trainees will be aware of the procedure for issue of an RVSM approval.

Content:

- Approval documents.

2.1.4 Topic: Suspension or Revocation of RVSM Approval.

Objective: Trainees will be aware of the procedure for the suspension or revocation of an RVSM approval.

Content:

- Occurrences to be reported.
- Operator's action.
- Reinstatement of approval.

2.2 Certification Requirements.

2.2.1 Topic: Airworthiness Requirements.

Objective: Trainees will be aware of the airworthiness requirements for RVSM approval

Content:

- Aircraft groupings.
- Flight envelopes.
- Performance data.
- Continued airworthiness.

2.2.2 Topic: Operational Requirements.

Objective: Trainees will be aware of the operational requirements for RVSM approval.

Content:

- Training programmes.
- Operating practices, procedures, manuals and checklists.

2.3 ACAS.

2.3.1 Topic: ACAS.

Objective: Trainees will be aware of the ACAS requirements for the AFI RVSM environment.

Content:

- ACAS II requirements.
- TCAS II Version 6.04A.
- TCAS II Version 7.

3. Safety and Monitoring. (Duration: 1 Period)

This module will provide the trainees with an awareness of the safety case and monitoring of RVSM

3.1 Safety.

3.1.1 Topic: Collision Risk Model.

Objective: Trainees will be aware of the state approval process.

Content:

- Responsibilities of the aircraft operator.

3.2 Monitoring.

3.2.1 Topic: The need for monitoring.

Objective: Trainees will be aware of the need to monitor.

Content:

- TLS

3.2.2 Topic: Height Monitoring Targets.

Objective: Trainees will be aware of the height monitoring targets.

Content:

- Height keeping errors.
- Monitoring targets.

3.2.3 Topic: Height Monitoring Systems.

Objective: Trainees will be aware of the height monitoring systems.

Content:

- HMU.
- GMU.
- Height monitoring programme.

4. Flight Planning. (Duration: 1 Period)

This module will provide the trainees with an awareness of the flight planning elements of RVSM.

4.1 Flight Planning.

4.1.1 Topic: Flight plans (FPL).

Objective: Trainees will be aware of the RVSM flight planning requirements for FPLs.

Content:

- RVSM specific inclusions for FPLs.

4.1.2 Topic: Repetitive flight plans (RPL).

Objective: Trainees will be aware of the RVSM flight planning requirements for RPLs.

Content:

- RVSM specific inclusions for RPLs.

5. Operational Procedures. (Duration: 3 Periods)

This module will provide the trainees with the ability to explain the RVSM Operational Procedures.

5.1 Overview.

5.1.1 Topic: Flight operations within the AFI RVSM airspace.

Objective: Trainees will explain the regulations governing flight operations within the AFI RVSM airspace.

Content:

- Aircraft restrictions.
- Flight conditions.
- Allocation of flight levels.

5.1.2 Topic: Provision of Service to Non-RVSM Approved State Aircraft.

Objective: Trainees will explain the general procedures governing the provision of service to non-RVSM approved State aircraft.

Content:

- Definition of State aircraft.
- Vertical separation minimum.

5.2 General Procedures.

5.2.1 Topic: General Procedures.

Objective: Trainees will explain the general procedures for operations within AFI RVSM airspace.

Content:

- Clearance into RVSM airspace.
- Minimum vertical separation between RVSM aircraft.
- Minimum vertical separation between non-RVSM aircraft and any other.
- Vertical separation minimum for transition task.
- Formation flights by civil aircraft and State aircraft.
- Flight level allocation to non-RVSM approved aircraft other than State aircraft.

5.2.2 Topic: Procedures for State Aircraft Operating as Operational Air Traffic, Crossing ATS Routes, Within the RVSM Airspace.

Objective: Trainees will explain the procedures for State aircraft operating as OAT crossing ATS Routes within the RVSM airspace.

Content:

- Definition of OAT.
- RVSM approval status for OAT.
- Minimum vertical separation.
- Vertical separation minimum where RVSM approval status is known.

5.2.3 Topic: Inter-Centre Co-ordination.

Objective: Trainees will explain the inter-centre co-ordination requirements.

Content:

- Computer-assisted co-ordination of estimate messages.
- Verbal co-ordination of estimate messages.

5.2.4 Topic: Contingency Procedures.

Objective: Trainees will explain the RVSM contingency procedures.

Content:

- Overview.
- Equipment- related procedures.
- Weather-related procedures.

5.2.5 Topic: Vertical Spacing from Prohibited, Restricted, Danger and Temporary Segregated Areas.

Objective: Trainees will explain the minimum vertical spacing associated with activity within Prohibited, Restricted, Danger and Temporary Segregated Areas.

Content:

- Delineation of airspace restrictions.
- Vertical spacing requirements.

5.3 Transition Procedures.

5.3.1 Topic: Traffic exiting RVSM airspace.

Objective: Trainees will explain the procedures applicable to aircraft leaving AFI RVSM airspace.

Content:

- Responsibility.
- Vertical separation minimum.
- Level allocation.

5.3.2 Topic: Traffic entering RVSM airspace.

Objective: Trainees will explain the procedures applicable to aircraft entering AFI RVSM airspace.

Content:

- Responsibility.
- Level allocation.

5.3.3 Topic: Aircraft landing within the lateral limits of RVSM airspace.

Objective: Trainees will explain the procedures applicable to aircraft landing within the lateral limits of RVSM airspace

Content:

- Responsibility.
- Level allocation.

5.3.4 Topic: Aircraft landing outside, and transiting the lateral limits of, RVSM airspace.

Objective: Trainees will explain the procedures applicable to aircraft landing outside, and transiting the lateral limits of, RVSM airspace.

- Content:**
- Responsibility.
 - Level allocation.

5.4 **Communications Failure in Flight.**

5.4.1 **Topic: Communications Failure in transition airspace.**

Objective: Trainees will explain the procedures applicable to aircraft within AFI RVSM transition airspace.

- Content:**
- RVSM airspace west or north of non-RVSM airspace.
 - RVSM airspace east or south of non-RVSM airspace.
 - Adaptation of route structures.
 - Adaptation of ATS local/regional agreements.
 - Combination of route structure and agreement adaptation.
 - General procedures.

5.4.2 **Topic: Communications Failure in Non-Transition RVSM Airspace**

Objective: Trainees will explain the procedures applicable to non-transition RVSM airspace.

- Content:**
- ICAO Communication Failure Procedure.

6. **Phraseology. (Duration: 1 Period)**

This module will provide the trainees with an appreciation for correct RVSM phraseologies.

6.1 **Phraseology.**

6.1.1 **Topic: Flight operations within the AFI RVSM airspace.**

Objective: Trainees will describe the correct controller-pilot RTF phraseology for given situations.

- Content:**
- To ascertain RVSM approval status.
 - Pilot indication of non-RVSM approval status.
 - Denial of clearance into RVSM airspace.
 - Non-compliance with RVSM due to turbulence.
 - Non-compliance with RVSM due to equipment failure.
 - Pilot indication of ability to resume RVSM operations.
 - Controller request for pilot ability to resume RVSM operations.

6.1.2 **Topic: Co-ordination between ATS Units.**

Objective: Trainees will describe the correct phraseology to be used in inter-unit co-ordination messages.

- Content:**
- Supplementary information to automated message exchange without Item 18.
 - Supplementary information on non-RVSM approved aircraft.
 - Supplementary information on contingency aircraft.

7. **Airspace Changes. (Duration: 1 Period)**

This module will provide the trainees with an appreciation for the possible changes to airspace structures offered by RVSM.

7.1 **Topic: Airspace Considerations.**

7.1.1 **Topic: Flight Level Allocation Scheme.**

Objective: Trainees will consider the impact of RVSM on existing Flight Level Allocation Schemes.

Content:

- Optimisation of existing FLAS.
- Strategic de-confliction of major crossing points.
- FLAS to and from transition areas.

7.1.2 **Topic: Sectorisation.**

Objective: Trainees will consider the impact of RVSM on sectorisation.

Content:

- Vertical limits of control sectors.
- Reduction in co-ordination of non-RVSM traffic.
- Sector boundary levels.
- Areas of Common Interest.

7.1.3 **Topic: Optimisation of ATS Route Structure.**

Objective: Trainees will consider the impact of RVSM on the existing route structures.

Content:

- Overview.
- Extension of uni-directional route structure.
- Creation of uni-directional routes in transition areas.

8. **Simulated Practical Exercises. (Duration: 24 Periods)**

This module will allow the trainees the opportunity to practice and demonstrate competence in various aspects related to RVSM in the operational environment.

8.1 **Topic: Simulated practical exercises.**

8.1.1 **Topic: Exercise 1.**

Objective: Introduce trainees to the application of RVSM in designated RVSM airspace.

Content:

- Approved aircraft.
- Application of information indicated on flight progress strips.
- Phraseology.
- Co-ordination with other sectors where RVSM is applied.

8.1.2 **Topic: Exercise 2.**

Objective: Introduce trainees to the application of RVSM in designated RVSM and adjoining transition airspace.

- Content:**
- Approved and state aircraft.
 - Non-approved aircraft.
 - Application of information indicated on flight progress strips.
 - Phraseology.
 - Co-ordination with other sectors where RVSM is applied and transition airspace.

8.1.3 Topic: Exercise 3.

Objective: Introduce trainees to the application of RVSM in designated RVSM and adjoining transition airspace whilst accommodating contingency procedures related to onboard equipment malfunction.

- Content:**
- Approved and state aircraft.
 - Non-approved aircraft.
 - Phraseology.
 - Application of information indicated on flight progress strips.
 - Co-ordination with other sectors where RVSM is applied and transition airspace.
 - Contingency procedures related to onboard equipment malfunction.

8.1.4 Topic: Exercise 4.

Objective: Introduce trainees to the application of RVSM in designated RVSM and adjoining transition airspace whilst accommodating contingency procedures related to weather.

- Content:**
- Approved and state aircraft.
 - Non-approved aircraft.
 - Phraseology.
 - Application of information indicated on flight progress strips.
 - Co-ordination with other sectors where RVSM is applied and transition airspace.
 - Contingency procedures related to weather.

8.1.5 Topic: Exercise 5.

Objective: Assess trainees in the application of RVSM in designated RVSM and adjoining transition airspace whilst accommodating contingency procedures related to weather and onboard equipment malfunction.

- Content:**
- Approved and state aircraft.
 - Non-approved aircraft.
 - Phraseology.
 - Application of information indicated on flight progress strips.
 - Co-ordination with other sectors where RVSM is applied and transition airspace.
 - Contingency procedures related to weather.

The assessment will be based only on the objectives related to RVSM. The aspects related to normal VSM and ATC operations will not be assessed since trainees will be competent on those aspects.

APPENDIX D

RVSM/RNAV/RNP/TF/3 Meeting Report

**Joint Aviation Authority (JAA) Temporary
Guidance Leaflet No.6 (TGL 6)**

JAA Administrative & Guidance Material
Section One: General Part 3: Temporary Guidance Leaflets

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

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

Revision 1 of this TGL deletes from this document the specific procedures for RVSM operations in Europe and for the North Atlantic, and refers for guidance on operational matters to the EUROCONTROL ATC Manual for RVSM in Europe and to the applicable ICAO material for the North Atlantic and other regions.

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PREAMBLE

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

The revised material of this leaflet is derived directly from IL 23. The material has been updated to reflect the current status of RVSM operations in general, and to add guidance concerning the application of RVSM within designated airspace in the EUR region (referred to as European RVSM airspace) as defined in ICAO Doc 7030/4. The opportunity has been taken also to make a number of editorial corrections and clarifications of the original text. These revisions include:

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

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

Revision marks in the left hand margin show the differences between this Revision and the first issue of TGL No. 6.

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

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1. PURPOSE

JAA Administrative & Guidance Material

Section One: General Part 3: Temporary Guidance Leaflets

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

2. RELATED REGULATIONS

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

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

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

3. RELATED READING MATERIAL

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

ICAO Document NAT/DOC/001, the Consolidated Guidance Material North Atlantic Region.

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

ICAO Document 9536, Review of the General Concept of Separation (RGCSP).

ICAO Document 7030/4, Regional Supplementary Procedures.

EUROCONTROL Document ASM.ET1.ST.5000. Manual for Reduced Vertical Separation (RVSM) in Europe.

4. BACKGROUND

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

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

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

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

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

- (a) airworthiness performance requirements in the form of a comprehensive Minimum Aircraft Systems Performance Specification (MASPS) for all aircraft which would be operated in RVSM airspace;
- (b) new operational procedures; and
- (c) a comprehensive means of monitoring for safe operation.

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

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

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

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

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Section One: General Part 3: Temporary Guidance Leaflets

- (a) JAA Information Leaflet No. 23: "Interim Guidance Material On The Approval Of Operators/ Aircraft For RVSM Operations", and
- (b) FAA Document 91-RVSM: "Interim Guidance for Approval of Operations/ Aircraft for RVSM Operations".

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

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

5. DEFINITIONS AND ABBREVIATIONS

Aircraft Group A group of aircraft that are of nominally identical design and build with respect to all details that could influence the accuracy of height keeping performance.

Altimetry System Error (ASE) The difference between the pressure altitude displayed to the flight crew when referenced to the International Standard Atmosphere ground pressure setting (1013.2 hPa /29.92 in.Hg) and free stream pressure altitude.

Assigned Altitude Deviation (AAD) The difference between the transmitted Mode C altitude and the assigned altitude/ flight level.

Automatic Altitude Control System Any system that is designed to automatically control the aircraft to a referenced pressure altitude.

Avionics Error (AVE) The error in the processes of converting the sensed pressure into an electrical output, of applying any static source error correction (SSEC) as appropriate, and of displaying the corresponding altitude.

Basic RVSM Envelope The range of Mach numbers and gross weights within the altitude ranges FL 290 to FL 410 (or maximum attainable altitude) where an aircraft can reasonably expect to operate most frequently.

Full RVSM Envelope The entire range of operational Mach numbers, W/ δ , and altitude values over which the aircraft can be operated within RVSM airspace.

General Air Traffic (GAT) Flights conducted in accordance with the rules and provisions of ICAO.

Height keeping Capability Aircraft height keeping performance that can be expected under nominal environmental operating conditions, with proper aircraft operating practices and maintenance.

Height keeping Performance The observed performance of an aircraft with respect to adherence to a flight level.

Non-Group Aircraft An aircraft for which the operator applies for approval on the characteristics of the unique airframe rather than on a group basis.

Operational Air Traffic (OAT) Flights which do not comply with the provisions stated for GAT and for which rules and procedures have been specified by appropriate authorities.

RVSM Approval The approval that is issued by the appropriate authority of the State in which the Operator is registered.

Residual Static Source Error The amount by which static source error (SSE) remains under-corrected or overcorrected after the application of SSEC.

State Aircraft Aircraft used in military, customs and police services shall be deemed to be State aircraft

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

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Static Source Error Correction (SSEC) A correction for static source error.

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

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

Abbreviation	Meaning
AAD	Assigned Altitude Deviation
ADC	Air Data Computer
AOA	Angle of Attack
AOC	Air Operator's Certificate
ASE	Altimetry System Error
ATS	Air Traffic Service
GAT	General Air Traffic
δ	Atmospheric Pressure Ratio
Hp	Pressure Altitude
hPa	Hecto-Pascals
in.Hg	Inches of Mercury
M	Mach number
MASPS	Minimum Aircraft System Performance Specification
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
Mmo	Maximum Operating Limit Mach
MNPS	Minimum Navigation Performance Specification
NAT	North Atlantic
NOTAM	Notice to Airmen
OAT	Operational Air Traffic
OTS	Organised Track Structure
QFE	Atmospheric pressure at aerodrome elevation (or at runway threshold)
QNH	Altimeter sub-scale setting to obtain elevation when on ground
RTF	Radio Telephony
SSE	Static Source Error
SSEC	Static Source Error Correction
TVE	Total Vertical Error
VMO	Maximum Operating Limit Velocity
W	Weight

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6. THE APPROVAL PROCESS

6.1 General

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

6.2 Approval of Aircraft

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

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

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

6.3 Operational Approval

For certain airspace, as defined by ICAO Regional Navigation Agreements, operators are required to hold State approval to operate in that airspace, which may or may not include RVSM. Paragraph 11 contains guidance on operational procedures that an operator may need to adopt for such airspace where RVSM is applied including advice on the operational material that may need to be submitted for review by the responsible authority.

7. RVSM PERFORMANCE

7.1 General

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

7.2 RVSM Flight Envelopes

For the purposes of RVSM approval, the aircraft flight envelope may be considered as two parts; the Basic RVSM flight planning envelope and the Full RVSM flight envelope (referred to as the Basic envelope and the Full envelope respectively), as defined in paragraph 5 and explained in 9.4. For the Full envelope, a larger ASE is allowed.

7.3 Altimetry System Error

7.3.1 To evaluate a system against the ASE performance statements established by RGCSP (see Appendix 5, paragraph 2), it is necessary to quantify the mean and three standard deviation values for ASE, expressed as ASE_{mean} and ASE_{3SD} . To do this, it is necessary to take into account the different ways in which variations in ASE can arise. The factors that affect ASE are:

- (a) Unit to unit variability of avionics equipment.
- (b) Effect of environmental operating conditions on avionics equipment.
- (c) Airframe to airframe variability of static source error.
- (d) Effect of flight operating conditions on static source error.

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7.3.2 Assessment of ASE, whether based on measured or predicted data will need to consider subparagraphs (a) to (d) of 7.3.1. The effect of item (d) as a variable can be eliminated by evaluating ASE at the most adverse flight condition in an RVSM flight envelope.

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

- (a) At the point in the envelope where the mean ASE reaches its largest absolute value that value should not exceed 25 m (80 ft);
- (b) At the point in the envelope where absolute mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 60 m (200 ft).

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

- (a) At the worst point in the Full envelope where the mean ASE reaches its largest absolute value, the absolute value should not exceed 37 m (120 ft).
- (b) At the point in the Full envelope where the mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 75 m (245 ft).
- (c) If necessary, for the purpose of achieving RVSM approval for a group of aircraft (see 9.3), an operating limitation may be established to restrict aircraft from conducting RVSM operations in parts of the Full envelope where the absolute value of mean ASE exceeds 37 m (120 ft) and/or the absolute value of mean ASE plus three standard deviations of ASE exceed 75 m (245 ft). When such a limitation is established, it should be identified in the data submitted to support the approval application, and documented in appropriate aircraft operating manuals. However, visual or aural warning/indication associated with such a limitation need not be provided in the aircraft.

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

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

- (a) For all conditions in the Basic envelope:
 - | Residual static source error + worst case avionics | ≤ 50 m (160 ft)
- (b) For all conditions in the Full envelope:
 - | Residual static source error + worst case avionics | ≤ 60 m (200 ft)

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

7.4 Altitude Keeping

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

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

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8. AIRCRAFT SYSTEMS

8.1 Equipment for RVSM Operations

The minimum equipment fit is:

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

- (a) Cross-coupled static source/system, with ice protection if located in areas subject to ice accretion;
- (b) Equipment for measuring static pressure sensed by the static source, converting it to pressure altitude and displaying the pressure altitude to the flight crew;
- (c) Equipment for providing a digitally encoded signal corresponding to the displayed pressure altitude, for automatic altitude reporting purposes;
- (d) Static source error correction (SSEC), if needed to meet the performance criteria of sub-paragraphs 7.3.3, 7.3.4 or 7.3.6, as appropriate; and
- (e) Signals referenced to a pilot selected altitude for automatic control and alerting. These signals will need to be derived from an altitude measurement system meeting the criteria of this document, and, in all cases, enabling the criteria of sub-paragraphs 8.2.6 and 8.3 to be met.

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

8.1.3 An altitude alerting system.

8.1.4 An automatic altitude control system.

8.2. Altimetry

8.2.1 *System Composition* The altimetry system of an aircraft comprises all those elements involved in the process of sampling free stream static pressure and converting it to a pressure altitude output. The elements of the altimetry system fall into two main groups:

- (a) Airframe plus static sources.
- (b) Avionics equipment and/or instruments.

8.2.2 *Altimetry System Outputs* The following altimetry system outputs are significant for RVSM operations:

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

8.2.3 *Altimetry System Accuracy* The total system accuracy will need to satisfy the criteria of sub-paragraphs 7.3.3, 7.3.4 or 7.3.6 as appropriate.

8.2.4 *Static Source Error Correction* If the design and characteristics of the aircraft and its altimetry system are such that the criteria of sub-paragraphs 7.3.3, 7.3.4 or 7.3.6 are not satisfied by the location and geometry of the static sources alone, then suitable SSEC will need to be applied automatically within the avionics equipment of the altimetry system. The design aim for static source error correction, whether applied by aerodynamic/ geometric means or within the avionics equipment, should be to produce a

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minimum residual static source error, but in all cases it should lead to compliance with the criteria of sub-paragraphs 7.3.3, 7.3.4 or 7.3.6, as appropriate.

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

8.2.6 *Altitude Control Output*

- (a) The altimetry system will need to provide a signal that can be used by an automatic altitude control system to control the aircraft to a selected altitude. The signal may be used either directly, or combined with other sensor signals. If SSEC is necessary to satisfy the criteria of sub-paragraph 7.3.3, 7.3.4 or 7.3.6, then an equivalent SSEC may be applied to the altitude control signal. The signal may be an altitude deviation signal, relative to the selected altitude, or a suitable absolute altitude signal.
- (b) Whatever the system architecture and SSEC system, the difference between the signal output to the altitude control system and the altitude displayed to the flight crew will need to be kept to the minimum.

8.2.7 *Altimetry System Integrity* The RVSM approval process will need to verify that the predicted rate of occurrence of undetected failure of the altimetry system does not exceed 1×10^{-5} per flight hour. All failures and failure combinations whose occurrence would not be evident from cross cockpit checks, and which would lead to altitude measurement /display errors outside the specified limits, need to be assessed against this value. Other failures or failure combinations need not be considered.

8.3 Altitude Alerting

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

8.4 Automatic Altitude Control System

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

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

8.5 System Limitations

8.5.1 The Aircraft Flight Manual should include a statement of compliance against this TGL (or equivalent guidance material) quoting the applicable Service Bulletin or build standard of the aircraft. In addition the following statement should be included:-

“Airworthiness Approval alone does not authorise flight into airspace for which an RVSM Operational Approval is required by an ICAO Regional Navigation Agreement.”

8.5.2 Non-compliant aspects of the installed systems and any other limitations will need to be identified in the approved Aircraft Flight Manual amendment or supplement, and in the applicable and approved Operations Manual.

For example:-

- Non-compliant altimeter systems, e.g. standby altimeter;
- Non-Compliant modes of the automatic pilot, e.g. altitude hold, vnav, altitude select;
- Weight Limit;
- Mach Limit;
- Altitude Limit.

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9. AIRWORTHINESS APPROVAL

9.1 General

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

9.1.2 For the first step:

- in the case of a newly built aircraft, the aircraft constructor develops and submits to the responsible authority of the state of manufacture, the performance and analytical data that supports RVSM airworthiness approval of a defined build standard. The data will be supplemented with maintenance and repair manuals giving associated continued airworthiness instructions. Compliance with RVSM criteria will be stated in the Aircraft Flight Manual including reference to the applicable build standard, related conditions and limitations. Approval by the responsible authority, and, where applicable, validation of that approval by other authorities, indicates acceptance of newly built aircraft, conforming to that type and build standard, as complying with the RVSM airworthiness criteria.
- in the case of an aircraft already in service, the aircraft constructor (or an approved design organisation), submits to the responsible authority, either in the state of manufacture or the state in which the aircraft is registered, the performance and analytical data that supports RVSM airworthiness approval of a defined build standard. The data will be supplemented with a Service Bulletin, or its equivalent, that identifies the work to be done to achieve the build standard, continued airworthiness instructions, and an amendment to the Aircraft Flight Manual stating related conditions and limitations. Approval by the responsible authority, and, where applicable, validation of that approval by other authorities, indicates acceptance of that aircraft type and build standard as complying with the RVSM airworthiness criteria.

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

9.1.4 For the second step, an aircraft operator may apply to the responsible authority of the state in which the aircraft is registered, for airworthiness approval of specific aircraft. The application will need to be supported by evidence confirming that the specific aircraft has been inspected and, where necessary, modified in accordance with applicable Service Bulletins, and is of a type and build standard that meets the RVSM airworthiness criteria. The operator will need to confirm also that the continued airworthiness instructions are available and that the approved Flight Manual amendment or supplement (see paragraph 8.5) has been incorporated. Approval by the authority indicates that the aircraft is eligible for RVSM operations. The authority will notify the designated monitoring cell accordingly.

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

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9.2 Contents of the RVSM Approval Data Package

As a minimum, the data package will need to consist of the following items:

- (a) A statement of the aircraft group or non-group aircraft and applicable build standard to which the data package applies.
- (b) A definition of the applicable flight envelope(s).
- (c) Data showing compliance with the performance criteria of paragraphs 7 and 8.
- (d) The procedures to be used to ensure that all aircraft submitted for airworthiness approval comply with RVSM criteria. These procedures will include the references of applicable Service Bulletins and the applicable approved Aircraft Flight Manual amendment or supplement.
- (e) The maintenance instructions that ensure continued airworthiness for RVSM approval.

The items listed in 9.2 are explained further in the following sub-paragraphs.

9.3 Aircraft Groupings

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

- (a) Aircraft should have been constructed to a nominally identical design and be approved on the same Type Certificate (TC), TC amendment, or Supplemental TC, as applicable.

Note: For derivative aircraft it may be possible to use the data from the parent configuration to minimise the amount of additional data required to show compliance. The extent of additional data required will depend on the nature of the differences between the parent aircraft and the derivative aircraft.

- (b) The static system of each aircraft should be nominally identical. The SSE corrections should be the same for all aircraft of the group.
- (c) The avionics units installed on each aircraft to meet the minimum RVSM equipment criteria of sub-paragraph 8.1 should comply with the manufacturer's same specification and have the same part number.

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

9.3.2 If an airframe does not meet the conditions of sub-paragraphs 9.3.1(a) to (c) to qualify as a member of a group, or is presented as an individual airframe for approval, then it will need to be considered as a non-group aircraft for the purposes of RVSM approval.

9.4 Flight Envelopes

The RVSM operational flight envelope, as defined in paragraph 5, is the Mach number, W/δ , and altitude ranges over which an aircraft can be operated in cruising flight within the RVSM airspace. Appendix 1 gives an explanation of W/δ . The RVSM operational flight envelope for any aircraft may be divided into two parts as explained below:

9.4.1 *Full RVSM Flight Envelope* The Full envelope will comprise the entire range of operational Mach number, W/δ , and altitude values over which the aircraft can be operated within RVSM airspace. Table 1 establishes the parameters to be considered.

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TABLE 1 - FULL RVSM ENVELOPE BOUNDARIES

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

9.4.2 *Basic RVSM Flight Planning Envelope* The boundaries for the Basic envelope are the same as those for the Full envelope except for the upper Mach boundary.

9.4.3 For the Basic envelope, the upper Mach boundary may be limited to a range of airspeeds over which the aircraft group can reasonably be expected to operate most frequently. This boundary should be declared for each aircraft group by the aircraft constructor or the approved design organisation. The boundary may be equal to the upper Mach/airspeed boundary defined for the Full envelope or a lower value. This lower value should not be less than the Long Range Cruise Mach Number plus 0.04 Mach, unless limited by available cruise thrust, buffet, or other flight limitations.

9.5 Performance Data

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

9.5.1 *General* ASE will generally vary with flight condition. The data package should provide coverage of the RVSM envelope sufficient to define the largest errors in the Basic and Full envelopes. In the case of group aircraft approval, the worst flight condition may be different for each of the criterion of sub-paragraph 7.3.3 and 7.3.4. Each should be evaluated.

9.5.2 Where precision flight calibrations are used to quantify or verify altimetry system performance they may be accomplished by any of the following methods. Flight calibrations should be performed only when appropriate ground checks have been completed. Uncertainties in application of the method will need to be assessed and taken into account in the data package.

- (a) Precision tracking radar in conjunction with pressure calibration of atmosphere at test altitude.
- (b) Trailing cone.
- (c) Pacer aircraft.
- (d) Any other method acceptable to the responsible authority.

Note: When using pacer aircraft, the pacer aircraft will need to be calibrated directly to a known standard. It is not acceptable to calibrate a pacer aircraft by another pacer aircraft.

9.5.3 *Altimetry System Error Budget* It is implicit in the intent of sub-paragraph 7.3, for group aircraft approvals and for non-group approvals, that a trade-off may be made between the various error sources which contribute to ASE. This document does not specify separate limits for the various error sources that contribute to the mean and variable components of ASE as long as the overall ASE accuracy criteria of sub-paragraph 7.3 are met. For example, in the case of an aircraft group approval, the smaller the mean of the group and the more stringent the avionics standard, the larger the available allowance for SSE variations. In all cases, the trade-off adopted should be presented in the data package in the form of an

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error budget that includes all significant error sources. This is discussed in more detail in the following sections. Altimetry system error sources are discussed in Appendix 2.

9.5.4 *Avionic Equipment* Avionic equipment should be identified by function and part number. A demonstration will need to show that the avionic equipment can meet the criteria established by the error budget when the equipment is operated in the environmental conditions expected to be met during RVSM operations.

9.5.5 *Groups of Aircraft* Where approval is sought for an aircraft group, the associated data package will need to show that the criteria of sub-paragraph 7.3.3 and 7.3.4 are met. Because of the statistical nature of these criteria, the content of the data package may vary considerably from group to group.

- (a) The mean and airframe-to-airframe variability of ASE should be established, based on precision flight test calibration of a number of aircraft. Where analytical methods are available, it may be possible to enhance the flight test data base and to track subsequent changes in the mean and variability based on geometric inspections and bench test, or any other method acceptable to the responsible authority. In the case of derivative aircraft it may be possible to use data from the parent as part of the data base. This may be applicable to a fuselage stretch where the only difference in mean ASE between groups could be reliably accounted for by analytical means.
- (b) An assessment of the aircraft-to-aircraft variability of each error source should be made. The error assessment may take various forms as appropriate to the nature and magnitude of the source and the type of data available. For example, for some error sources (especially small ones), it may be acceptable to use specification values to represent three standard deviations. For other error sources (especially larger ones) a more comprehensive assessment may be required. This is especially true for airframe error sources where specification values of ASE contribution may not have been previously established.
- (c) In many cases, one or more of the major ASE error sources will be aerodynamic in nature, such as variations in the airframe surface contour in the vicinity of the static pressure source. If evaluation of these errors is based on geometric measurements, substantiation should be provided that the methodology used is adequate to ensure compliance. An example of the type of data that could be used to provide this substantiation is provided in Appendix 3, figure 3-2.
- (d) An error budget should be established to ensure that the criteria of sub-paragraphs 7.3.3 and 7.3.4 are met. As noted in 9.5.1, the worst condition experienced in flight may differ for each criterion and therefore the component error values may also differ.
- (e) In showing compliance with the overall criteria, the component error sources should be combined appropriately. In most cases this will involve the algebraic summation of the mean components of the errors, root-sum-square (rss) combination of the variable components of the errors, and summation of the rss value with the absolute value of the overall mean. Care should be taken that only variable component error sources that are independent of each other are combined by rss.
- (f) The methodology described above for group approval is statistical. This is the result of the statistical nature of the risk analysis and the resulting statements of Appendix 5 sub-paragraphs 5(a) and 5(b). In the context of a statistical method, the statements of Appendix 5, sub-paragraph 5(c) need further explanation. This item states that 'each individual aircraft in the group shall be built to have an ASE contained within $\pm 60\text{m}$ ($\pm 200\text{ ft}$)'. This statement has not been taken to mean that every airframe should be calibrated with a trailing cone or equivalent to demonstrate that ASE is within $\pm 60\text{m}$ (200 ft). Such an interpretation would be unduly onerous considering that the risk analysis allows for a small proportion of aircraft to exceed 60m (200 ft). However, it is accepted that if any aircraft is identified as having an error exceeding $\pm 60\text{m}$ ($\pm 200\text{ ft}$) then it should receive corrective action.

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9.5.6 *Non-group Aircraft* When an aircraft is submitted for approval as a non-group aircraft, as explained in sub-paragraph 9.3.2, the data should be sufficient to show that the criteria of sub-paragraph 7.3.6 are met. The data package should specify how the ASE budget has been allocated between residual SSE and avionics error. The operator and responsible authority should agree on what data is needed to satisfy approval criteria. The following data should be established:

- (a) Precision flight test calibration of the aircraft to establish its ASE or SSE over the RVSM envelope. Flight calibration should be performed at points in the flight envelope(s) as agreed by the responsible authority. One of the methods listed in sub-paragraphs 9.5.2 (a) to (d) should be used.
- (b) Calibration of the avionics used in the flight test as required to establish residual SSE. The number of test points should be agreed by the responsible authority. Since the purpose of the flight test is to determine the residual SSE, specially calibrated altimetry equipment may be used.
- (c) Specifications for the installed altimetry avionics equipment, identifying the largest allowable errors.

Using the foregoing, compliance with the criteria of sub-paragraph 7.3.6 should be demonstrated. If, subsequent to aircraft approval for RVSM operation, avionic units that are of a different manufacturer or part number are fitted, it should be demonstrated that the standard of avionic equipment provides equivalent altimetry system performance.

9.6 Compliance Procedures

The data package will need to define the procedures, inspections and tests, and the limits that will be used to ensure that all aircraft approved against the data package 'conform to type'; that is all future approvals, whether of new build or in-service aircraft, meet the budget allowances developed according to sub-paragraph 9.5.3. The budget allowances will be established by the data package and include a methodology that allows for tracking the mean and standard deviation for new build aircraft. Limits will need to be defined for each potential source of error. A discussion of error sources is provided in Appendix 2. Examples of procedures are presented in Appendix 3. Where an operating limitation has been applied, the package should contain the data and information necessary to document and establish that limitation.

9.7 Continued Airworthiness

9.7.1 The following items should be reviewed and updated as applicable to RVSM:

- (a) The Structural Repair Manual with special attention to the areas around each static source, angle of attack sensors, and doors if their rigging can affect airflow around the previously mentioned sensors.
- (b) The Master Minimum Equipment List (MMEL).

9.7.2 The data package should include details of any special procedures that are not covered in sub-paragraph 9.7.1, but may be needed to ensure continued compliance with RVSM approval criteria. Examples follow:

- (a) For non-group aircraft, where airworthiness approval has been based on flight test, the continuing integrity and accuracy of the altimetry system will need to be demonstrated by ground and flight tests of the aircraft and its altimetry system at periods to be agreed with the responsible authority. However, alleviation of the flight test requirement may be given if it can be demonstrated that the relationship between any subsequent airframe/system degradation and its effects on altimetry system accuracy is understood and that it can be compensated or corrected.
- (b) In-flight defect reporting procedures should be defined to aid identification of altimetry system error sources. Such procedures could cover acceptable differences between primary and alternate static sources, and others as appropriate.

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

9.8 Post Approval Modification

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

10. CONTINUED AIRWORTHINESS (MAINTENANCE PROCEDURES)

10.1 General

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

10.2 Maintenance Programmes

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

10.3 Maintenance Documents

The following items should be reviewed, as appropriate:

- (a) Maintenance Manuals.
- (b) Structural Repair Manuals.
- (c) Standard Practices Manuals.
- (d) Illustrated Parts Catalogues.
- (e) Maintenance Schedule.
- (f) MMEL.

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10.4 Maintenance Practices

If the operator is subject to an approved maintenance programme, that programme should include, for each aircraft type, the maintenance practices stated in the applicable aircraft and component manufacturers' maintenance manuals. In addition, for all aircraft, including those not subject to an approved maintenance programme, attention should be given to the following items:

- (a) All RVSM equipment should be maintained in accordance with the component manufacturers' maintenance instructions and the performance criteria of the RVSM approval data package.
- (b) Any modification or design change which in any way affects the initial RVSM approval, should be subject to a design review acceptable to the responsible authority.
- (c) Any repairs, not covered by approved maintenance documents, that may affect the integrity of the continuing RVSM approval, e.g. those affecting the alignment of pitot/static probes, repairs to dents or deformation around static plates, should be subject to a design review acceptable to the responsible authority.
- (d) Built-in Test Equipment (BITE) testing should not be used for system calibration unless it is shown to be acceptable by the aircraft constructor or an approved design organisation, and with the agreement of the responsible authority.
- (e) An appropriate system leak check (or visual inspection where permitted) should be accomplished following reconnection of a quick-disconnect static line.
- (f) Airframe and static systems should be maintained in accordance with the aircraft constructor's inspection standards and procedures.
- (g) To ensure the proper maintenance of airframe geometry for proper surface contours and the mitigation of altimetry system error, surface measurements or skin waviness checks will need to be made, as specified by the aircraft constructor, to ensure adherence to RVSM tolerances. These checks should be performed following repairs, or alterations having an effect on airframe surface and airflow.
- (h) The maintenance and inspection programme for the autopilot will need to ensure continued accuracy and integrity of the automatic altitude control system to meet the height keeping standards for RVSM operations. This requirement will typically be satisfied with equipment inspections and serviceability checks.
- (i) Whenever the performance of installed equipment has been demonstrated to be satisfactory for RVSM approval, the associated maintenance practices should be verified to be consistent with continued RVSM approval. Examples of equipment to be considered are:
 - (i) Altitude alerting.
 - (ii) Automatic altitude control system.
 - (iii) Secondary surveillance radar altitude reporting equipment.
 - (iv) Altimetry systems.

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

- (a) The failure or malfunction is confirmed and isolated; and,
- (b) Corrective action is taken as necessary to comply with sub-paragraph 9.5.5 (f) and verified to support RVSM approval.

10.4.2 *Maintenance Training* New training may be necessary to support RVSM approval. Areas that may need to be highlighted for initial and recurrent training of relevant personnel are:

- (a) Aircraft geometric inspection techniques.
- (b) Test equipment calibration and use of that equipment.
- (c) Any special instructions or procedures introduced for RVSM approval.

10.4.3 *Test Equipment*

- (a) The test equipment should have the capability to demonstrate continuing compliance with all the parameters established in the data package for RVSM approval or as approved by the responsible authority.
- (b) Test equipment should be calibrated at periodic intervals as agreed by the responsible authority using reference standards whose calibration is certified as being traceable to national standards acceptable to that authority. The approved maintenance programme should include an effective quality control programme with attention to the following:
 - (i) Definition of required test equipment accuracy.
 - (ii) Regular calibrations of test equipment traceable to a master standard. Determination of the calibration interval should be a function of the stability of the test equipment. The calibration interval should be established using historical data so that degradation is small in relation to the required accuracy.
 - (iii) Regular audits of calibration facilities both in-house and outside.
 - (iv) Adherence to approved maintenance practices.
 - (v) Procedures for controlling operator errors and unusual environmental conditions which may affect calibration accuracy.

11. OPERATIONAL APPROVAL

11.1 Purpose and Organisation

Paragraph 6 gives an overview of the RVSM approval processes. For airspace where operational approval is required, this paragraph describes steps to be followed and gives detailed guidance on the required operational practices and procedures. Appendices 4 and 5 are related to this paragraph and contain essential information for operational programmes.

11.2 RVSM Operations

Approval will be required for each aircraft group and each aircraft to be used for RVSM operations. Approval will be required for each operator and the responsible authority will need to be satisfied that

- (a) each aircraft holds airworthiness approval according to paragraph 9;
- (b) each operator has continued airworthiness programmes (maintenance procedures) according to paragraph 10;

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- (c) where necessary, operating procedures unique to the airspace have been incorporated in operations manuals including any limitations identified in paragraph 8.5.
- (d) high levels of aircraft height keeping performance can be maintained.

11.3 Content of Operator RVSM Application

The following material should be made available to the responsible authority, in sufficient time to permit evaluation, before the intended start of RVSM operations.

- (a) *Airworthiness Documents* Documentation that shows that the aircraft has RVSM airworthiness approval. This should include an Approved Flight Manual amendment or supplement.
- (b) *Description of Aircraft Equipment* A description of the aircraft appropriate to operations in an RVSM environment.
- (c) *Training Programmes and Operating Practices and Procedures* Holders of Air Operators Certificates (AOC) may need to submit training syllabi for initial, and where appropriate, recurrent training programmes together with other appropriate material to the responsible authority. The material will need to show that the operating practices, procedures and training items, related to RVSM operations in airspace that requires State operational approval, are incorporated. Non-AOC operators will need to comply with local procedures to satisfy the responsible authority that their knowledge of RVSM operating practices and procedures is equivalent to that set for AOC Holders, sufficient to permit them to conduct RVSM operations. Guidance on the content of training programmes and operating practices and procedures is given in Appendix 4. In broad terms, this covers flight planning, pre-flight procedures, aircraft procedures before RVSM airspace entry, in-flight procedures, and flight crew training procedures. The procedures used within airspace of the EUR region and the procedures unique to the North Atlantic Airspace for which specific State operational approval is required are stated in Doc 7030/4.
- (d) *Operations Manuals and Checklists* The appropriate manuals and checklists should be revised to include information/guidance on standard operating procedures as detailed in Appendix 4. Manuals should include a statement of the airspeeds, altitudes and weights considered in RVSM aircraft approval; including identification of any operating limitations or conditions established for that aircraft group. Manuals and checklists may need to be submitted for review by the authority as part of the application process.
- (e) *Past Performance* Relevant operating history, where available, should be included in the application. The applicant should show that changes needed in training, operating or maintenance practices to improve poor height keeping performance, have been made.
- (f) *Minimum Equipment List* Where applicable, a minimum equipment list (MEL), adapted from the master minimum equipment list (MMEL) and relevant operational regulations, should include items pertinent to operating in RVSM airspace.
- (g) *Maintenance* When application is made for operational approval, the operator should establish a maintenance programme acceptable to the responsible authority, as detailed in paragraph 10.
- (h) *Plan for Participation in Verification/Monitoring Programmes* The operator should establish a plan acceptable to the responsible authority, for participation in any applicable verification/ monitoring programme (See 11.6). This plan will need to include, as a minimum, a check on a sample of the operator's fleet by an independent height monitoring system.

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11.4 Demonstration Flight(s)

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

11.5 Form of Approval Documents

- (a) *Holders of an Air Operator's Certificate* Approval to operate in designated RVSM airspace areas will be granted by an Approval issued by the responsible authority in accordance with JAR OPS 1, or in compliance with national regulations where operational approval is required by an ICAO Regional Agreement. Each aircraft group for which the operator is granted approval will be listed in the Approval.
- (b) *Non AOC Holders* These operators will be issued with an Approval as required by national regulations or with JAR OPS 2 when this JAR is published. These approvals will be valid for a period specified in national regulations, typically 2 years, and may require renewal.

Note: Subject to compliance with applicable criteria, an RVSM Approval combining the airworthiness approval of sub-paragraph 9.1.4 and the operational approval of paragraph 11.2 may be available from some authorities.

11.6 Airspace Monitoring

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

11.7 Suspension, Revocation and Reinstatement of RVSM Approval

The incidence of height keeping errors that can be tolerated in an RVSM environment is small. It is expected of each operator to take immediate action to rectify the conditions that cause an error. The operator should report an occurrence involving poor height keeping to the responsible authority within 72 hours. The report should include an initial analysis of causal factors and measures taken to prevent repeat occurrences. The need for follow up reports will be determined by the responsible authority. Occurrences that should be reported and investigated are errors of:

- (a) TVE equal to or greater than ± 90 m (± 300 ft),
- (b) ASE equal to or greater than ± 75 m (± 245 ft), and
- (c) Assigned altitude deviation equal to or greater than ± 90 m (± 300 ft).

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

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

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

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

11.7.3 *Operators Actions* The operator should make an effective, timely response to each height keeping error. The responsible authority may consider suspending or revoking RVSM approval if the

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operator's responses to height keeping errors are not effective or timely. The responsible authority will consider the operator's past performance record in determining the action to be taken.

11.7.4 *Reinstatement of Approval* The operator will need to satisfy the responsible authority that the causes of height keeping errors are understood and have been eliminated and that the operator's RVSM programmes and procedures are effective. At its discretion and to restore confidence, the authority may require an independent height monitoring check of affected aircraft to be performed.

12. AVAILABILITY OF DOCUMENTS

- 12.1 Copies of EUROCONTROL documents may be requested from EUROCONTROL Documentation Centre, GS4, Rue de la Fusee, 96, B-1130 Brussels, Belgium: (Fax: 32 2 729 9109), and on the internet at < <http://www.eur-rvsm.com> >.
- 12.2 Copies of FAA documents may be obtained from Superintendent of Documents, Government Printing Office, Washington DC 20402-9325, USA.
- 12.3 Copies of ARINC documents may be obtained from Aeronautical radio Inc., 2551 Riva Road, Annapolis, Maryland 24101-7465, USA.
- 12.4 Copies of RTCA documents may be obtained from RTCA Inc., 1140 Connecticut Avenue, N.W., Suite 1020, Washington, DC 20036-4001, USA, (Tel: 1 202 833 9339).
- 12.5 Information for obtaining ICAO and JAA documents should be requested from the applicant's national authority. (Information for obtaining the North Atlantic MNPS Airspace Operational Manual may be found in UK CAA AIC 149/1998).

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APPENDIX 1 - EXPLANATION OF W/δ

1 Sub-paragraph 9.4 describes the range of flight conditions over which conformity with the ASE criteria should be shown. The description includes reference to the parameter W/δ . The following discussion is provided for the benefit of readers who may not be familiar with the use of this parameter.

2 It would be difficult to show all of the gross weight, altitude, and speed conditions which constitute the RVSM envelope(s) on a single plot. This is because most of the speed boundaries of the envelopes are a function of both altitude and gross weight. As a result, a separate chart of altitude versus Mach would be required for each aircraft gross weight. Aircraft performance engineers commonly use the following technique to solve this problem.

3 For most jet transports the required flight envelope can be collapsed to a single chart with good approximation, by the use of the parameter W/δ (weight divided by atmospheric pressure ratio). This fact is due to the relationship between W/δ and the fundamental aerodynamic variables M and lift coefficient as shown below.

$$W/\delta = 1481.4 C_L M^2 S_{\text{Ref}}, \text{ where:}$$

δ = ambient pressure at flight altitude divided by sea level standard pressure of 1013.25 hPa

W/δ = Weight over Atmospheric Pressure Ratio

C_L = Lift Coefficient

M = Mach Number

S_{REF} = Reference Wing Area

4 As a result, the RVSM flight envelope(s) may be collapsed into one chart by simply plotting W/δ , rather than altitude, versus Mach Number. Since δ is a fixed value for a given altitude, weight can be obtained for a given condition by simply multiplying the W/δ value by δ .

5 Over the RVSM altitude range, it is a good approximation to assume that position error is uniquely related to Mach Number and W/δ for a given aircraft.

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APPENDIX 2 - ALTIMETRY SYSTEM ERROR COMPONENTS

1. INTRODUCTION

Sub-paragraph 9.5.3 states that an error budget should be established and presented in the approval data package. The error budget is discussed in some detail in subsequent paragraphs for group and non-group aircraft. The purpose of this appendix is to provide guidance to help ensure that all the potential error sources are identified and included in the error budget for each particular model.

2. OBJECTIVE OF ASE BUDGET

2.1 The purpose of the ASE budget is to demonstrate that the allocation of tolerances amongst the various parts of the altimetry system is, for the particular data package, consistent with the overall statistical ASE criteria. These individual tolerances within the ASE budget also form the basis of the procedures, defined in the airworthiness approval data package, which will be used to demonstrate that aircraft satisfy the RVSM criteria.

2.2 It is necessary to ensure that the budget takes account of all contributory components of ASE.

2.3 For group approval it is necessary to ensure either that the budget assesses the combined effect of the component errors in a way that is statistically realistic, or that the worst case specification values are used.

3. ALTIMETRY SYSTEM ERROR

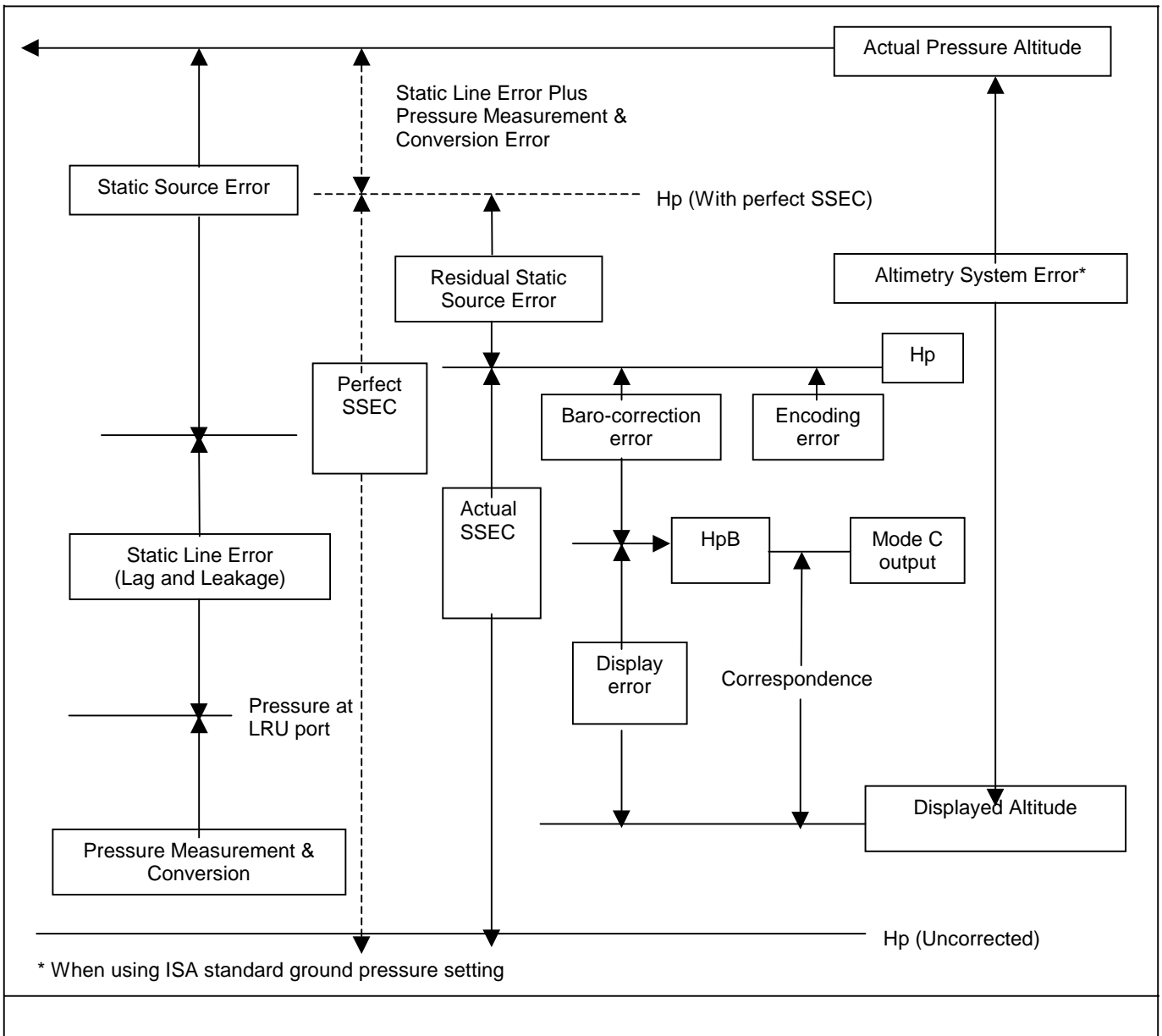
3.1 Breakdown

Figure 2-1 shows the breakdown of total ASE into its main components, with each error block representing the error associated with one of the functions needed to generate a display of pressure altitude. This breakdown encompasses all altimetry system errors that can occur, although different system architectures may combine the components in slightly different ways.

- (a) The 'Actual Altitude' is the pressure altitude corresponding to the undisturbed ambient pressure.
- (b) 'Static Source Error' is the difference between the undisturbed ambient pressure and the pressure within the static port, at the input end of the static pressure line.
- (c) 'Static Line Error' is any difference in pressure along the length of the line.
- (d) 'Pressure Measurement and Conversion Error' is the error associated with the processes of sensing the pneumatic input seen by the avionics, and converting the resulting pressure signal into altitude. As drawn, Figure 2-1 represents a self-sensing altimeter system in which the pressure measurement and altitude conversion functions would not normally be separable. In an air data computer system the two functions would be separate, and SSEC would probably then be applied before pressure altitude (H_p) was calculated.
- (e) 'Perfect SSEC' would be that correction that compensated exactly for the SSE actually present at any time. If such a correction could be applied, then the resulting value of H_p calculated by the system would differ from the actual altitude only by the static line error plus the pressure measurement and conversion error. In general this cannot be achieved, so although the 'Actual SSEC' can be expected to reduce the effect of SSE, it will do so imperfectly.

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FIGURE 2-1 ALTIMETRY SYSTEM ERRORS



(f) 'Residual Static Source Error' is applicable only in systems applying an avionic SSEC. It is the difference between the SSE and the correction actually applied. The corrected value of Hp will therefore differ from actual pressure altitude by the sum of static line error, pressure measurement and conversion error, and residual SSE.

(g) Between Hp and displayed altitude occur the baro-correction error and the display error. Figure 2-1 represents their sequence for a self-sensing altimeter system. Air data computer systems can implement baro-correction in a number of ways that would modify slightly this part of the block diagram, but the errors would still be associated with either the baro-correction function or the display function. The only exception is that those systems that can be switched to operate the display directly from the Hp signal can eliminate baro-correction error where standard ground pressure setting is used, as in RVSM operations.

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3.2 Components

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

3.2.1 *Static Source Error* The component parts of SSE are presented in Table 2-1, with the factors that control their magnitude.

- (a) The reference SSE is the best estimate of actual SSE, for a single aircraft or an aircraft group, obtained from flight calibration measurements. It is variable with operating condition characteristically reducing to a family of W/δ curves that are functions of Mach. It includes the effect of any aerodynamic compensation that may have been incorporated in the design. Once determined, the reference SSE is fixed for the single aircraft or group, although it may be revised when considering subsequent data.
- (b) The test techniques used to derive the reference SSE will have some measurement of uncertainty associated with them, even though known instrumentation errors will normally be eliminated from the data. For trailing-cone measurements the uncertainty arises from limitations on pressure measurement accuracy, calibration of the trailing-cone installation, and variability in installations where more than one are used. Once the reference SSE has been determined, the actual measurement error is fixed, but as it is unknown it can only be handled within the ASE budget as an estimated uncertainty.
- (c) The airframe variability and probe/port variability components arise from differences between the individual airframe and probe/port, and the example(s) of airframe and probe port used to derive the reference SSE.

3.2.2 *Residual Static Source Error*

- (a) The components and factors are presented in Table 2-1. Residual SSE is made up of those error components which make actual SSE different from the reference value, components 2, 3, and 4 from Table 2-1, plus the amount by which the actual SSEC differs from the value that would correct the reference value exactly, components 2(a), (b) and (c) from Table 2-2.
- (b) There will generally be a difference between the SSEC that would exactly compensate the reference SSE, and the SSEC that the avionics is designed to apply. This arises from practical avionics design limitations. The resulting error component 2(a) will therefore be fixed, for a particular flight condition, for the single aircraft or group. Additional variable errors 2(b) and 2(c) arise from those factors that cause a particular set of avionics to apply an actual SSEC that differs from its design value.
- (c) The relationship between perfect SSEC, reference SSEC, design SSEC and actual SSEC is illustrated in Figure 2-2, for the case where static line errors and pressure measurements and conversion errors are taken as zero.
- (d) Factors that create variability of SSE relative to the reference characteristic should be accounted for twice. First, as noted for the SSE itself in Table 2-2, and secondly for its effect on the corruption of SSEC as in factor 2(a)(i) of Table 2-2. Similarly the static pressure measurement error should be accounted for in two separate ways. The main effect will be by way of the 'pressure measurement and conversion' component, but a secondary effect will be by way of factor 2(a)(ii) of Table 2-2.

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

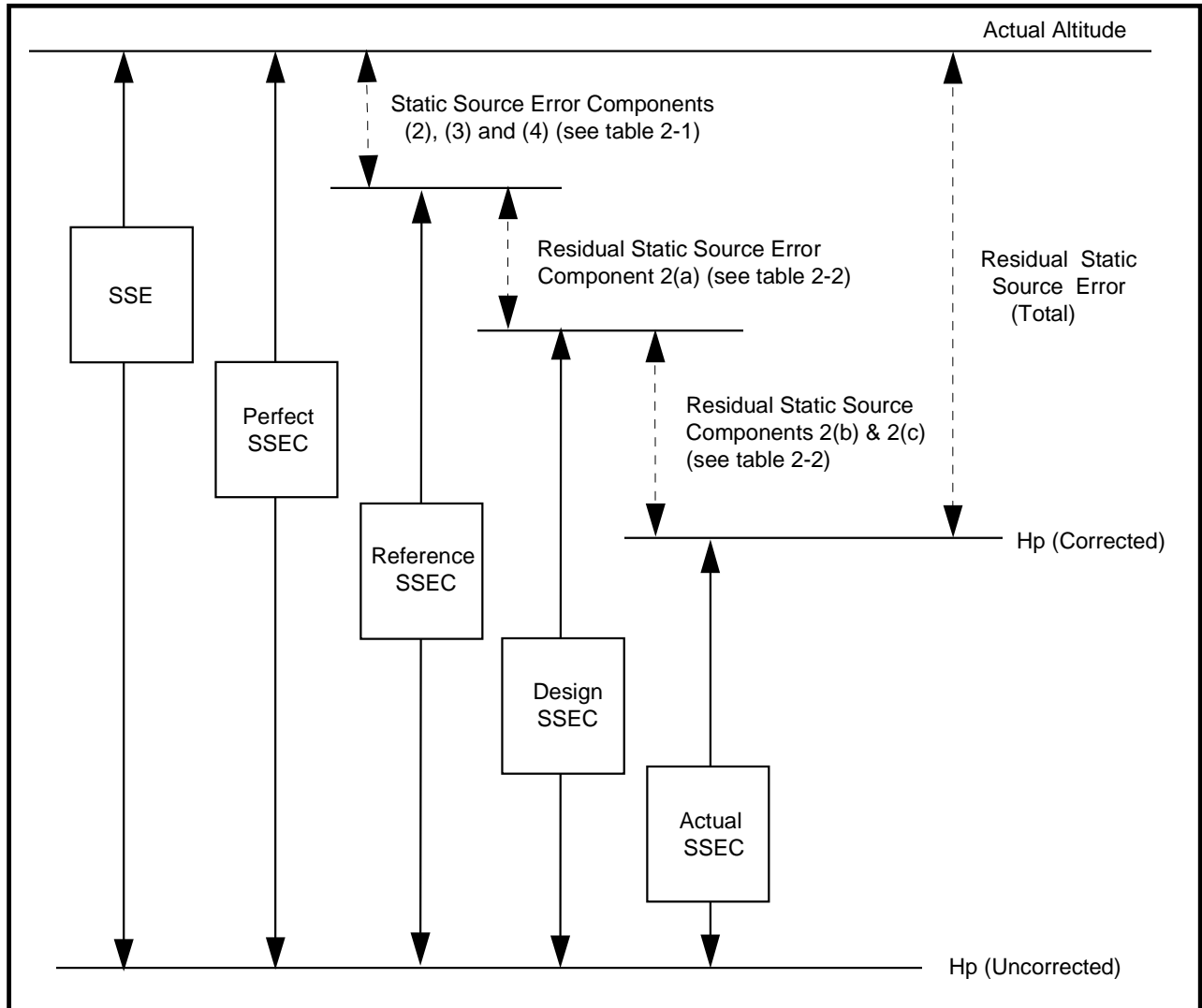
Factors	Error Components
Airframe Effects Operating Condition (Speed, altitude, angle of attack, sideslip) Geometry: Size and shape of airframe; Location of static sources; Variations of surface contour near the sources; Variations in fit of nearby doors, skin panels or other items.	1) Reference SSE values from flight calibration measurements. 2) Uncertainty of flight calibration measurements.
Probe/Port Effects Operating Condition (Speed, altitude, angle of attack, sideslip) Geometry: Shape of probe/port; Manufacturing variations; Installation variations.	3) Airframe to airframe variability. 4) Probe/port to probe/port variability.

TABLE 2-2 RESIDUAL STATIC SOURCE ERROR: (AIRCRAFT WITH AVIONIC SSEC)
(Cause: Difference between the SSEC actually applied and the actual SSE)

Factors	Error Components
(1) As for Static Source Error PLUS (2) Source of input data for SSEC function (a) Where SSEC is a function of Mach: (i) P_S sensing: difference in SSEC from reference SSE. (ii) P_S measurement: pressure transduction error. (iii) P_T errors: mainly pressure transduction error. (b) Where SSEC is a function of angle of attack: (i) geometric effects on alpha: -sensor tolerances; -installation tolerances; -local surface variations. (ii) measurement error: -angle transducer accuracy. (3) Implementation of SSEC function (a) Calculation of SSEC from input data; (b) Combination of SSEC with uncorrected height.	1) Error Components (2), (3), and (4) from table 2-1 PLUS 2(a) Approximation in fitting design SSEC to flight calibration reference SSE. 2(b) Effect of production variability (sensors and avionics) on achieving design SSEC. 2(c) Effect of operating environment (sensors and avionics) on achieving design SSEC.

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



3.2.3 *Static Line Error* Static line errors arise from leaks and pneumatic lags. In level cruise these can be made negligible for a system that is correctly designed and correctly installed.

3.2.4 *Pressure Measurement and Conversion Error*

- (a) The functional elements are static pressure sensing, which may be mechanical, electromechanical or solid-state, and the conversion of pressure signal to pressure altitude.
- (b) The error components are:
 - (i) calibration uncertainty;
 - (ii) nominal design performance;
 - (iii) unit to unit manufacturing variations; and
 - (iv) effect of operating environment.

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- (c) The equipment specification is normally taken to cover the combined effect of the error components. If the value of pressure measurements and conversion error used in the error budget is the worst case specification value, then it is not necessary to assess the above components separately. However, calibration uncertainty, nominal design performance and effect of operating environment can all contribute to bias errors within the equipment tolerance. Therefore if it is desired to take statistical account of the likely spread of errors within the tolerance band, then it will be necessary to assess their likely interaction for the particular hardware design under consideration.
- (d) It is particularly important to ensure that the specified environmental performance is adequate for the intended application.

3.2.5 *Baro-Setting Error* This is the difference between the value displayed and the value applied within the system. For RVSM operation the value displayed should always be the International Standard Atmosphere ground pressure, but setting mistakes, although part of TVE, are not components of ASE.

- (a) The components of Baro-Setting Error are:
 - (i) resolution of setting knob/display;
 - (ii) sensing of displayed value; and
 - (iii) application of sensed value.
- (b) The applicability of these factors and the way that they combine depend on the particular system architecture.
- (c) For systems in which the display is remote from the pressure measurement function there may be elements of the sensing and/or application or sensed value error components which arise from the need to transmit and receive the setting between the two locations.

3.2.6 *Display Error* The cause is imperfect conversion from altitude signal to display.

The components are:

- (a) conversion of display input signal;
- (b) graticule/format accuracy, and
- (c) readability.

3.2.7 In self-sensing altimeters the first of these would normally be separate from the pressure measurement and conversion error.

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APPENDIX 3 - ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

1. INTRODUCTION

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

2. EXAMPLE 1

2.1 One process for showing compliance with RVSM criteria is shown in Figure 3-1. Figure 3-1 illustrates those flight test calibrations and geometric inspections will be performed on a given number of aircraft. The flight calibrations and inspections will continue until a correlation between the two is established. Geometric tolerances and SSEC will be established to satisfy RVSM criteria. For aircraft being manufactured, every Nth aircraft will be inspected in detail and every Mth aircraft will be flight test calibrated, where 'N' and 'M' are determined by the aircraft constructor and agreed to by the responsible authority. The data generated by 'N' inspections and 'M' flight calibrations can be used to track the mean and three standard deviation values to ensure continued compliance of the model with the criteria of paragraph 7. As additional data are acquired, they should be reviewed to determine if it is appropriate to change the values of N and M as indicated by the quality of the results obtained.

2.2 There are various ways in which the flight test and inspection data might be used to establish the correlation. The example shown in Figure 3-2 is a process in which each of the error sources for several aeroplanes is evaluated based on bench tests, inspections and analysis. Correlation between these evaluations and the actual flight test results would be used to substantiate the method.

2.3 The method illustrated in Figures 3-1 and 3-2 is appropriate for new models since it does not rely on any pre-existing data base for the group.

3. EXAMPLE 2

3.1 Figure 3-3 illustrates that flight test calibrations should be performed on a given number of aircraft and consistency rules for air data information between all concerned systems verified. Geometric tolerances and SSEC should be established to satisfy the criteria. A correlation should be established between the design tolerances and the consistency rules. For aircraft being manufactured, air data information for all aircraft should be checked for consistency in cruise conditions and every Mth aircraft should be calibrated, where M is determined by the manufacturer and agreed to by the responsible authority. The data generated by the M flight calibrations should be used to track the mean and three standard deviation values to ensure continued compliance of the group with the criteria of paragraph 7.

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

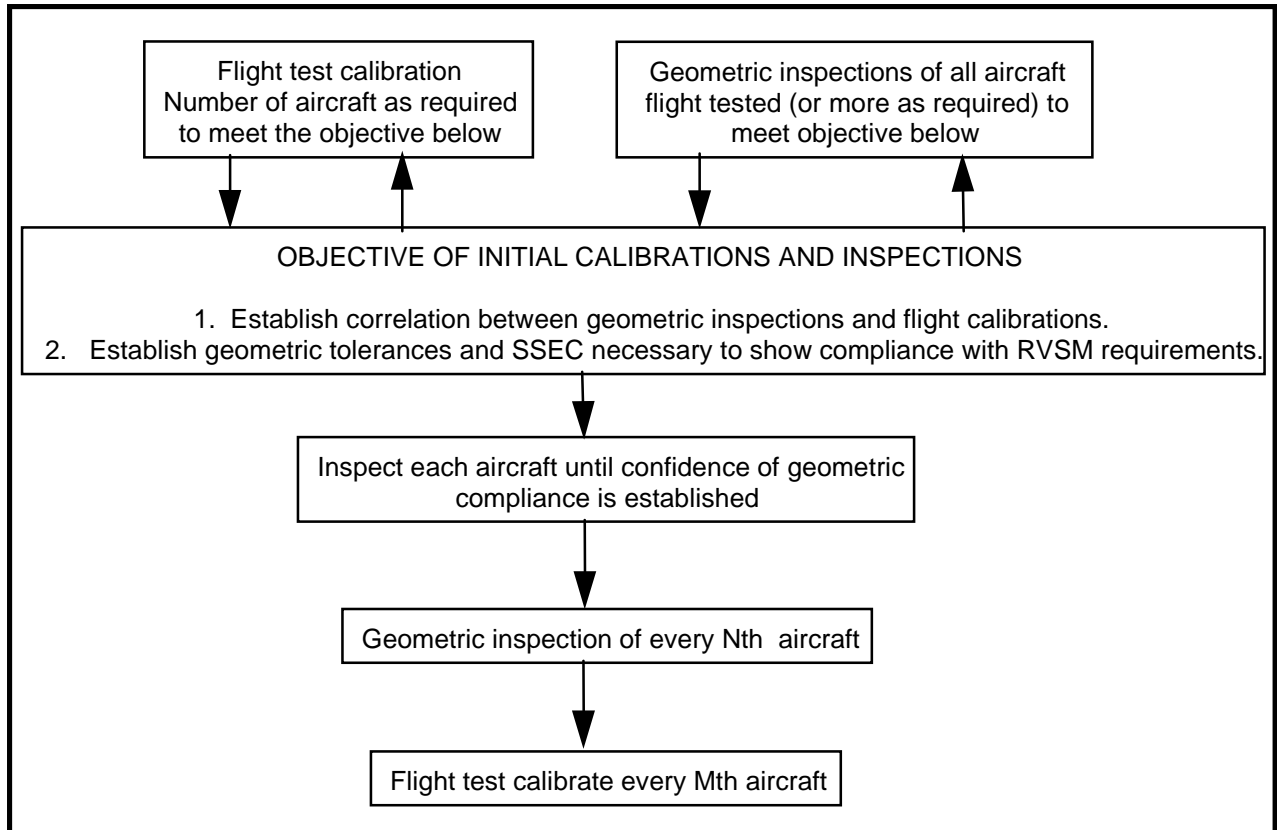
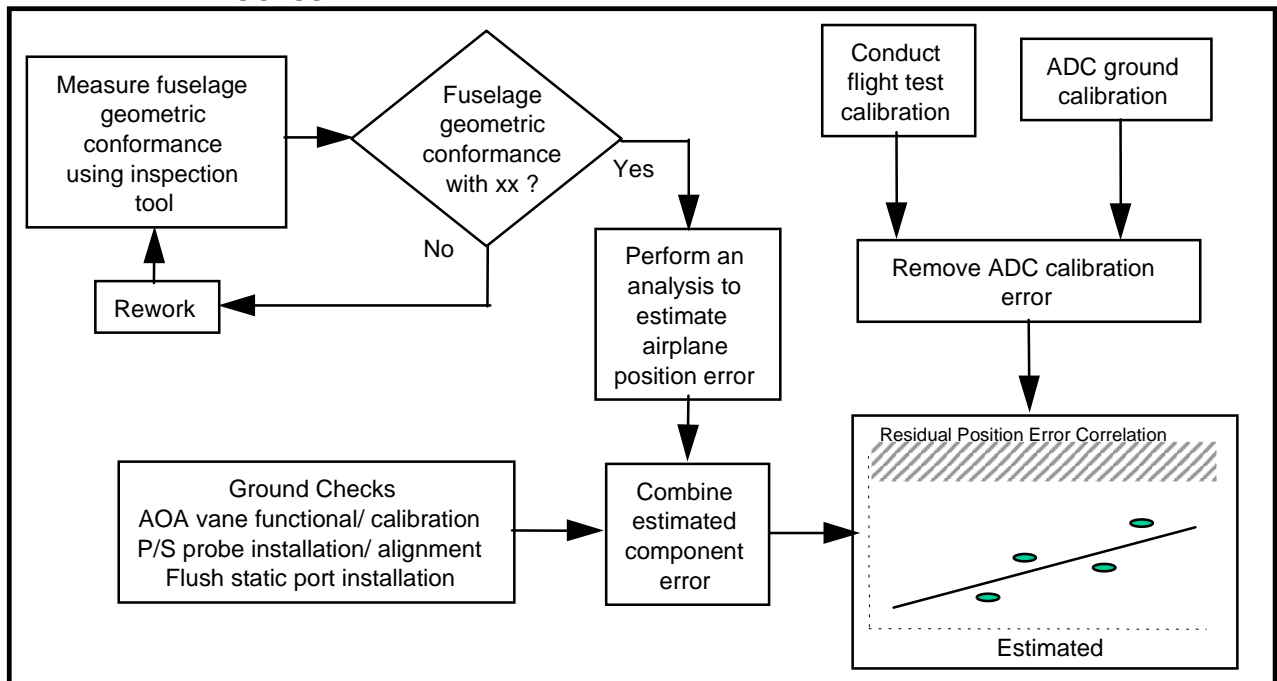
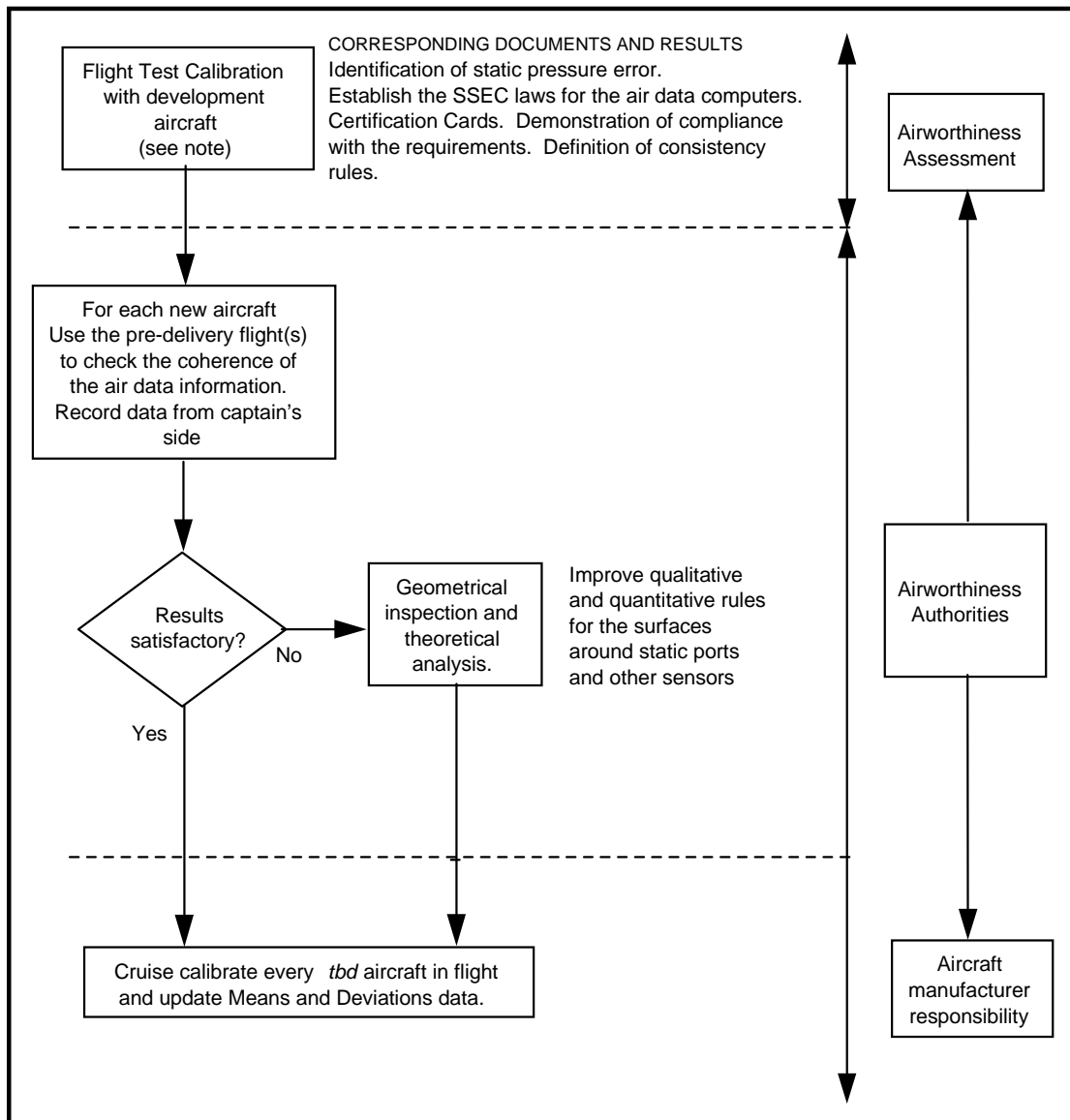


FIGURE 3-2 COMPLIANCE DEMONSTRATION GROUND - TO FLIGHT TEST CORRELATION PROCESS EXAMPLE



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



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

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APPENDIX 4 TRAINING PROGRAMMES AND OPERATING PRACTICES AND PROCEDURES

1. INTRODUCTION

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

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

2. FLIGHT PLANNING

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

These include, but may not be limited to:

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

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

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

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

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

- (d) before take-off, equipment required for flight in RVSM airspace should be operative, and any indications of malfunction should be resolved.

4. PROCEDURES PRIOR TO RVSM AIRSPACE ENTRY

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

- (a) Two primary altitude measurement systems.
- (b) One automatic altitude-control system.
- (c) One altitude-alerting device.

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

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

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

5. IN-FLIGHT PROCEDURES

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

- (a) Flight crews will need to comply with any aircraft operating restrictions, if required for the specific aircraft group, e.g. limits on indicated Mach number, given in the RVSM airworthiness approval.
- (b) Emphasis should be placed on promptly setting the sub-scale on all primary and standby altimeters to 1013.2 (hPa) /29.92 in.Hg when passing the transition altitude, and rechecking for proper altimeter setting when reaching the initial cleared flight level;
- (c) In level cruise it is essential that the aircraft is flown at the cleared flight level. This requires that particular care is taken to ensure that ATC clearances are fully understood and followed. The aircraft should not intentionally depart from cleared flight level without a positive clearance from ATC unless the crew are conducting contingency or emergency manoeuvres;
- (d) When changing levels, the aircraft should not be allowed to overshoot or undershoot the cleared flight level by more than 45 m (150 ft);

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

- (e) An automatic altitude-control system should be operative and engaged during level cruise, except when circumstances such as the need to re-trim the aircraft or turbulence require disengagement. In any event, adherence to cruise altitude should be done by reference to one of the two primary altimeters. Following loss of the automatic height keeping function, any consequential restrictions will need to be observed.
- (f) Ensure that the altitude-alerting system is operative;
- (g) At intervals of approximately one hour, cross-checks between the primary altimeters should be made. A minimum of two will need to agree within ± 60 m (± 200 ft). Failure to meet this condition will require that the altimetry system be reported as defective and notified to ATC;
- (i) The usual scan of flight deck instruments should suffice for altimeter cross-checking on most flights.
- (ii) Before entering RVSM airspace, the initial altimeter cross check of primary and standby altimeters should be recorded
Note: Some systems may make use of automatic altimeter comparators.
- (h) In normal operations, the altimetry system being used to control the aircraft should be selected for the input to the altitude reporting transponder transmitting information to ATC.

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- (i) If the pilot is advised in real time that the aircraft has been identified by a height-monitoring system as exhibiting a TVE greater than ± 90 m (± 300 ft) and/or an ASE greater than ± 75 m (± 245 ft) then the pilot should follow established regional procedures to protect the safe operation of the aircraft. This assumes that the monitoring system will identify the TVE or ASE within the set limits for accuracy.
- (j) If the pilot is notified by ATC of an assigned altitude deviation which exceeds ± 90 m (± 300 ft) then the pilot should take action to return to cleared flight level as quickly as possible.

5.2 Contingency procedures after entering RVSM airspace are:

5.2.1 The pilot should notify ATC of contingencies (equipment failures, weather) which affect the ability to maintain the cleared flight level, and co-ordinate a plan of action appropriate to the airspace concerned. Detailed guidance on contingency procedures are contained in the relevant publications dealing with the airspace. Refer to Appendix 4, Paragraph 8 of this document.

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

- (a) failure of all automatic altitude-control systems aboard the aircraft;
- (b) loss of redundancy of altimetry systems;
- (c) loss of thrust on an engine necessitating descent; or
- (d) any other equipment failure affecting the ability to maintain cleared flight level;

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

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

6. POST FLIGHT

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

6.2 The following information should be recorded when appropriate:

- (a) Primary and standby altimeter readings.
- (b) Altitude selector setting.
- (c) Subscale setting on altimeter.
- (d) Autopilot used to control the aeroplane and any differences when an alternative autopilot system was selected.
- (e) Differences in altimeter readings, if alternate static ports selected.
- (f) Use of air data computer selector for fault diagnosis procedure.
- (g) The transponder selected to provide altitude information to ATC and any difference noted when an alternative transponder was selected.

7. SPECIAL EMPHASIS ITEMS: FLIGHT CREW TRAINING

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

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- (a) knowledge and understanding of standard ATC phraseology used in each area of operations;
- (b) importance of crew members cross checking to ensure that ATC clearances are promptly and correctly complied with;
- (c) use and limitations in terms of accuracy of standby altimeters in contingencies. Where applicable, the pilot should review the application of static source error correction/ position error correction through the use of correction cards;

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

- (d) problems of visual perception of other aircraft at 300m (1,000 ft) planned separation during darkness, when encountering local phenomena such as northern lights, for opposite and same direction traffic, and during turns; and
- (e) characteristics of aircraft altitude capture systems which may lead to overshoots;
- (f) relationship between the aircraft's altimetry, automatic altitude control and transponder systems in normal and abnormal conditions;
- (g) any airframe operating restrictions, if required for the specific aircraft group, related to RVSM airworthiness approval.

8. SPECIFIC REGIONAL OPERATIONAL PROCEDURES

- 8.1 The areas of applicability (by Flight Information Region) of RVSM airspace in identified ICAO regions is contained in the relevant sections of ICAO Document 7030/4. In addition these sections contain operational and contingency procedures unique to the regional airspace concerned, specific flight planning requirements, and the approval requirements for aircraft in the designated region.
- 8.2 For the North Atlantic Minimum Navigation Performance Specification (MNPS) airspace, where RVSM have been in operation since 1997, further guidance (principally for State Approval Agencies) is contained in ICAO Document NAT 001 T13/5NB.5 with comprehensive operational guidance (aimed specifically at aircraft operators) in the North Atlantic MNPS Airspace Operational Manual.
- 8.3 Comprehensive guidance on operational matters for European RVSM Airspace is contained in EUROCONTROL Document ASM ET1.ST.5000 entitled "The ATC Manual for a Reduced Vertical Separation (RVSM) in Europe" with further material included in the relevant State Aeronautical Publications.
- 8.4 During the life of this document, it is expected that additional ICAO regions or parts of regions may introduce RVSM into their airspace. For example, plans are well in hand to introduce RVSM into parts of the Pacific region. The area of applicability and associated procedures will be published in Document 7030/4 where reference will be made to additional material as necessary.

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

1. ICAO Document 9574 Manual on the implementation of a 300m (1,000 ft) Vertical Separation Minimum Between FL 290-FL 410 Inclusive, covers the overall analysis of factors for achieving an acceptable level of safety in a given airspace system. The major factors are passing frequency, lateral navigation accuracy, and vertical overlap probability. Vertical overlap probability is a consequence of errors in adhering accurately to the assigned flight level, and this is the only factor covered in this document.

2. In ICAO Doc. 9574, Section 2.1.1.3, the vertical overlap probability requirement is restated as the aggregate of height keeping errors of individual aircraft that must lie within the total vertical error (TVE) distribution, expressed as the simultaneous satisfaction of the following four criteria:

- (a) " the proportion of height keeping errors beyond 90 m (300 ft) in magnitude must be less than 2.0×10^{-3} ; and
- (b) the proportion of height keeping errors beyond 150 m (500 ft) in magnitude must be less than 3.5×10^{-6} ; and
- (c) the proportion of height keeping errors beyond 200 m (650 ft) in magnitude must be less than 1.6×10^{-7} ; and
- (d) the proportion of height keeping errors between 290 m (950 ft) and 320 m (1,050 ft) in magnitude must be less than 1.7×10^{-8} . "

3. The following characteristics presented in ICAO Doc. 9574 were developed in accordance with the conclusions of ICAO Doc. 9536. They are applicable statistically to individual groups of nominally identical aircraft operating in the airspace. These characteristics describe the performance that the groups need to be capable of achieving in service, exclusive of human factors errors and extreme environmental influences, if the airspace system TVE criteria are to be satisfied. The following characteristics are the basis for development of this document:

- (a) 'The mean altimetry system error (ASE) of the group shall not exceed ± 25 m (± 80 ft); and
- (b) The sum of the absolute value of the mean ASE for the group and three standard deviations of ASE within the group shall not exceed 75 m (245 ft); and
- (c) Errors in altitude keeping shall be symmetric about a mean of 0 m (0 ft) and shall have a standard deviation not greater than 13 m (43 ft) and should be such that the error frequency decreases with increasing error magnitude at a rate which is at least exponential.'

4. ICAO Doc. 9574 recognises that specialist study groups would develop the detailed specifications, to ensure that the TVE objectives can be met over the full operational envelope in RVSM airspace for each aircraft group. In determining the breakdown of tolerances between the elements of the system it was considered necessary to set system tolerances at levels that recognise that the overall objectives must be met operationally by aircraft and equipment subject to normal production variability, including that of the airframe static source error, and normal in-service degradation. It was also recognised that it would be necessary to develop specifications and procedures covering the means for ensuring that in-service degradation is controlled at an acceptable level.

5. On the basis of studies reported in ICAO Doc. 9536, Volume 2, ICAO Doc. 9574 recommended that the required margin between operational performance and design capability should be achieved by ensuring that the performance criteria are developed to fulfil the following, where the narrower tolerance in sub-paragraph 5 (b) is specifically intended to allow for some degradation with increasing age:

- (a) 'the mean uncorrected residual position error (static source error) of the group shall not exceed ± 25 m (± 80 ft); and
- (b) the sum of the absolute value of the mean ASE for the group and three standard deviations of ASE within the group, shall not exceed 60 m (200 ft); and

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- (c) each individual aircraft in the group shall be built to have ASE contained within ± 60 m (± 200 ft); and
- (d) an automatic altitude control system shall be required and will be capable of controlling altitude within a tolerance band of ± 15 m (± 50 ft) about selected altitude when operated in the altitude hold mode in straight and level flight under non-turbulent, non-gust conditions.'

6. These standards provide the basis for the separate performance aspects of airframe, altimetry, altimetry equipment and automatic altitude control system. It is important to recognise that the limits are based on studies (Doc. 9536, Volume 2), which show that ASE tends to follow a normal distribution about a characteristic mean value for the aircraft group and that the in-service performances of the separate groups aggregate together to give an overall performance spread which is distributed about the population mean TVE that is nominally zero. Consequently, controls should be provided which will preclude the possibility that individual aircraft approvals could create clusters operating with a mean significantly beyond 25 m (80 ft) in magnitude, such as could arise where elements of the altimetry system generate bias errors additional to the mean corrected static source error.

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**AFRICA- INDIAN OCEAN RVSM SAMPLE
AIC, NOTAM, AIP SUPPLEMENT**

AERONAUTICAL INFORMATION CIRCULAR (AIC)

IMPLEMENTATION OF REDUCED VERTICAL SEPARATION MINIMA (RVSM) IN (.....) FIR

FIR/Airspace : (.....)

Effective date : 20 January 2005.

Type : Permanent/Temporary

Appendix – A

This AIC serves as Notice of Intent to implement RVSM in the (.....) FIR effective 20 January 2005.

Reduced Vertical Separation Minimum (RVSM) is vertical separation of aircraft by 1,000 ft above FL 290. By 20 November 2004, operators should have received RVSM aircraft (airworthiness) and operational approval from the appropriate State authority. Operator/aircraft approval by 20 November 2004 will enable air traffic services (ATS) to plan for orderly RVSM implementation.

Starting 20 January 2005, only RVSM compliant aircraft will be cleared to operate in the (.....) FIR between FL290 and FL410 (inclusive). Aircraft that are not RVSM compliant (e.g., ferry and maintenance flights) will only be cleared to operate in the (.....) FIR between FLs 290 and FL410 (inclusive) after prior co-ordination with the appropriate center. 2,000 ft vertical separation will be applied to such aircraft. (.....) center contacts will be published on websites (if established) and in follow-up NOTAMs.

RVSM will be implemented in the (.....) FIR in accordance with ICAO regional agreements. ICAO recommends that State authorities and operators use FAA Interim Guidance 91-RVSM (as amended); Joint Airworthiness Authorities (JAA) Temporary Guidance Leaflet 6 (TGL 6) or equivalent State documents as the basis for approving aircraft and operator programs for RVSM.

The AFI Region has established that the task of monitoring safety in conjunction with implementation of RVSM and RNAV/RNP in the AFI Region be assigned to the South Africa. Current information and RVSM approval documents, including revisions, can be found on the website maintained by the FAA, EUROCONTROL, SATMA, MECMA and on individual State websites.

To access the FAA, EUROCONTROL, SATMA and MECMA RVSM websites, type :

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

<http://www.eur-rvsm.com>

<http://www.satmasat.com>

<http://www.mecma.com>

The RVSM Documentation section of the FAA, EUROCONTROL websites contain guidance on aircraft/operator approval. Operators must begin coordination with the appropriate State authority as soon as possible to ensure that they are approved to begin RVSM operations on 20 January 2005.

Further information on the aircraft and operator approval process, policy planning and implementation issues for RVSM can be obtained from South Africa (ATNS) being responsible for setting up the AFI Regional Monitoring Agency.

NOTAM RELATED TO FLIGHT LEVEL ALLOCATION

In relation with the implementation of the RVSM in the AFI Region (see AIC and AIP/AMDT.....) and in order to avoid the excessive FL's changes for the users, the AFI Region Flight Level Allocation will be established based on the anticipated date to implement RVSM in selected airspace by the AIRAC cycle date of 20 January 2005, concurrently with the CAR/SAM Region.

CRUISING LEVELS APPLICABLE IN AFI RVSM AIRSPACE

The cruising levels that will apply within AFI region airspace will be in accordance with ICAO Annex 2, Appendix 3 a).

All ATS Routes in the upper airspace :

Eastbound Track from 000° to 179° : ODD LEVELS; 410,390,370,350,330,310,290

Westbound Track from 180° to 359° : EVEN LEVELS; 400,380,360,340,320,300

Operators are requested to plan their flights under this flight levels allocation scheme.

TEXT TO NOTAM FOR SUSPENSION OF RVSM

Procedures for Suspension of RVSM

Air Traffic Service providers will consider suspending RVSM procedures within affected area within theFIR and adjacent transition areas when there are pilot reports of greater than moderate turbulence. Within areas where RVSM procedures are suspended, the vertical separation minimum between all aircraft will be 2,000 ft.

AIP SUPPs FOR THE IMPLEMENTATION OF RVSM WITHIN THE (.....) FIR

(NAME OF STATE)

Address : AIP SUPPLEMENT N°
Telephone : DATE OF PUBLICATION
Fax :
E-mail :
Other information:

(to be developed)
