INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

REPORT OF THE TENTH MEETING OF THE APANPIRG ATS/AIS/SAR SUB-GROUP (ATS/AIS/SAR/SG/10)

Bangkok, Thailand, 26 – 30 June 2000

The views expressed in this Report should be taken as those of
The Group and not the Organization

Approved by the Meeting
And published by authority of the Secretary General

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PART I – HISTORY OF THE MEETING

1. Introduction

1.1 The tenth meeting of the APANPIRG Air Traffic Services/Aeronautical Information Services/Search and Rescue Sub-Group (ATS/AIS/SAR/SG/10) was held at the ICAO Asia and Pacific Regional Office, Bangkok, Thailand between 26 to 30 June 2000.

2. Attendance

2.1 The meeting was attended by 58 participants from 22 States and 1 International Organization and 1 Aviation Industry Organization. A list of participants is given at Attachment 1.

3 Officers and Secretariat

3.1 Mr. George P.S. Chao acted as Chairman and Mr. Robert Deavin acted as Vice Chairman of the Sub-Group. They presided over the meeting throughout its duration.

3.2 Mr. John E. Richardson, Regional Officer, ATM, ICAO Asia/Pacific Office, was Secretary of the meeting and was assisted by Messrs. Owen Dell and Hiroshi Inoguchi.

4. Language and Documentation

4.1 The discussions were conducted in English. Documentation was issued in English with a total of 25 Working Papers and 2 Information Papers being considered by the meeting. A list of papers presented during the meeting is included in Attachment 2 to this report.

5. Opening of the Meeting

5.1 The meeting was opened by Mr. John Richardson, who welcomed the participants to Bangkok and on behalf of the ICAO Regional Representative, Mr. L.B. Shah, conveying a message wishing the meeting every success in its deliberations.

5.2 The Chairman added his words of welcome to the participants and outlined the work programme before the Sub-Group.

6. Draft Conclusions and Draft Decisions - Definition

6.1 The ATS/AIS/SAR Sub-Group records its actions in the form of Draft Conclusions and Draft Decisions with the following significance:

a) **Draft Conclusions** deal with matters that, according to terms of reference, merit directly the attention of States, or on which further action is required to be initiated by the Secretariat according to established procedures; and

b) **Draft Decisions** relate solely to matters dealing with the internal working arrangements of the Sub-Group.

6.2 **List of Draft Conclusions**

Draft Conclusion 10/2 – Guidance Material on the Implementation of a 300 m (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Asia Pacific Region

Draft Conclusion 10/3 – SAR Capability Matrix

Draft Conclusion 10/4 – Mandatory Carriage & Operation of Pressure Altitude Reporting Transponders

Draft Conclusion 10/5 – Implementation of ACAS II

Draft Conclusion 10/7 – Revised ATS route structure – Southeast Asia to/from Europe/Middle East, South of the Himalayas

Draft Conclusion 10/8 – Methodology which may be used in Future Work Projects

6.3 **List of Draft Decisions**

Draft Decision 10/10 – ATS/AIS/SAR Subject/Task List

6.4 **List of Decisions**

Decision 10/1 – Revised Terms of Reference for ICAO RVSM Implementation Task Force

Decision 10/6 – Dissolve the Bay of Bengal Task Force

Decision 10/9 – Revised Terms of Reference for the AIS Automation Task Force

PART II – REPORT ON AGENDA ITEMS

Agenda Item 1: Adoption of Provisional Agenda

1.1 The meeting reviewed the following provisional agenda presented by the Secretariat and adopted it as the agenda for the meeting.

Agenda Item 1: Adoption of Provisional Agenda

Agenda Item 2: Review the APANPIRG/10 Report and subsequent ANC/Council Actions with respect to ATS/AIS/SAR issues

Agenda Item 3: Review and progress the tasks assigned to the ATS/AIS/SAR/SG by APANPIRG

Agenda Item 4: Consider problems and make specific recommendations concerning the provision of ATS/AIS/SAR in the Asia/Pacific Region

Agenda Item 5: Y2K Contingency Planning for the Asia/Pacific Region – Actions taken and Benefits derived

Agenda Item 6: Review progress of AAIS/AATF/6

Agenda Item 7: Shortcomings and Deficiencies in the Air Navigation field

Agenda Item 8: Update the list of ATS/AIS/SAR Subject/Tasks together with priorities

Agenda Item 9: Any other business

Agenda Item 10: Date and venue for next meeting

Agenda Item 2: Review the APANPIRG/10 Report and subsequent ANC/Council Actions with respect to ATS/AIS/SAR issues

2.1 The meeting reviewed Decisions and Conclusions of the APANPIRG/10 with respect to ATS/AIS/SAR matters. The meeting noted the actions which had been taken and also determined the current status of ATS/AIS/SAR related conclusions and decisions developed by the APANPIRG/10 meeting.

2.1.1 Actions in regard to these matters has been described in other agenda items of this Report.

2.2 **Outstanding Conclusions/Decisions of APANPIRG in ATS/AIS/SAR Fields**

2.2.1 The meeting reviewed the outstanding Conclusions/Decisions of APANPIRG in the fields of ATS/AIS/SAR and updated actions relating to them undertaken by States and ICAO. The updated list is at Appendix A to the Report on Agenda Item 2.

2.3 **Work by APANPIRG Sub-Group Work Programme Review Task Force**

2.3.1 The meeting was advised that in reviewing the work of the Sub-Groups, the APANPIRG/10 meeting was of the opinion that the CNS/ATM/IC Sub-Group was only meeting part of its charter. The CNS/ATM/IC Sub-Group is providing a very important venue for the exchange of information and updates on activities within the region. The meeting noted, however, that the CNS/ATM/IC Sub-Group was unable to fully perform the “co-ordination” function.

2.3.2 Due to the diverse sources of information to the CNS/ATM/IC Sub-Group from ALLPIRG, APANPIRG, COM/MET/NAV/SUR/SG, ATS/AIS/SAR/SG and States, the meeting was of the opinion that a Task Force should be formed to review the present tasks of all the sub-groups and key issues. The Task Force should comprise the three Sub-Group Chairpersons and the ICAO Secretariat.

2.3.3 The meeting noted that the Task Force was tasked to develop a consolidated action plan to reflect the present and future work activities of APANPIRG sub-groups. The plan so developed will be reviewed and approved by APANPIRG. Revision of the action plan will then be undertaken whenever it was considered necessary. Accordingly the APANPIRG/10 developed the following decision:

Decision 10/45 - APANPIRG Sub-Group Work Programme Review Task Force

That, a Sub-Group Work Programme Review Task Force be established with the following Terms of Reference:

a) recommend a consolidated action plan taking into consideration outcome of ALLPIRG meetings, Sub-Groups’ work, Tasks and Key Issues for the implementation of CNS/ATM in the Region;

b) recommend an effective reporting process which identifies progress against key priorities and

c) consider any other relevant issues such as intra and inter regional coordination requirements and recommend inclusion of appropriate tasks in the work programme.

2.3.4 The Task Force met from 20 to 22 March 2000 at the ICAO Regional Office, Bangkok to develop a consolidated action plan to reflect the present and future work activities of APANPIRG sub-groups. The Task Force considered the role and functions of the sub-groups and subsequently reached the following recommendations:

(a) that the CNS/ATM/IC Sub-Group be dissolved
(b) that the other two sub-groups be renamed as ATM/AIS/SAR Sub-Group and CNS/MET Sub-Group
(c) that the Terms of Reference of the remaining two sub-groups be revised.

2.3.5 Having considered all the issues, the meeting, in general, was in support of the above recommendations. One State felt that owing to resource constraint, States might have difficulties in sending representatives from different fields to attend the Sub-Group meetings. It was pointed out, however, that the change would not impose additional resources from the States as the operational work of CNS/ATM was already currently being undertaken by the ATS/AIS/SAR and COM/MET/NAV/SUR Sub-Groups. The States, on the contrary, would only need in future to send representatives to the two sub-group meetings instead of three.

OUTSTANDING CONCLUSIONS/DECISIONS OF APANPIRG IN ATS/AIS/SAR FIELDS

Report Reference ---------------- Conc/Dec No	Action by ANC/ Council	Decision/Conclusion Title/ ANC/Council Action, if any	Action by States/ICAO	Status
C 2/28		**Implementation of Area Control Service**	States to classify airspace in accordance with SARPS and update AIPs; provide area control service on appropriate ATS routes and ensure AIPs reflect correct ATS provision. Most States have completed the action required. This action is part of the work programme of relevant ATS Co-ordination meetings. Non-implementation will be included on list of Shortcoming and Deficiencies.	On-going
C 3/24		**Implementation of RVSM & RNP in the Pacific Region**	a) RVSM was implemented in the Pacific Region on 24 February 2000 b) RNP-10 has been implemented in most of the Pacific Region	Completed On-going
C 4/2	 C	**States in the Asia Region to review their SAR system** Noted the Conclusion**.**	Review of Asian States SAR is continuing. The ICAO Regional Office is actively fostering the enhancement of SAR throughout the Region as part of the normal work programme. Shortcomings and Deficiencies will be listed as they become apparent.	On-going
C 6/13		**SAR Agreements**	A register has not yet been established. Monitoring undertaken by ATS/AIS/SAR/SG.	On-going
C 6/19	 C	**Japan Area "G"** Noted the conclusion and requested the Secretary General to pursue the subject as a matter of high priority and report the outcome to the Council and inform the APANPIRG accordingly.	The Task has been removed from the work programme of ATS/AIS/SAR/SG. No progress could be made by the Secretariat on this subject.	 On-going
D 6/21		**Guidelines for the Construction of ATS Routes**	No longer a requirement due to the recent publication of a number of ICAO provisions including The Manual on Airspace Planning for the Determination of Separation Minima (Doc 9689) and the 2nd Edition of the Manual on Required Navigation Performance (RNP).	Completed

Report Reference ---------------- Conc/Dec No	Action by ANC/ Council	Decision/Conclusion Title/ ANC/Council Action, if any	Action by States/ICAO	Status
C 7/7	ANC	**GPS RAIM Outage Notification** Noted the conclusion	This item has been overtaken by time and technology. There is no longer a requirement for an implementation plan to be developed.	Completed
C 8/9	ANC	**Co-ordinated Activity - SAR** Noted the conclusion and requested the Secretary General to take appropriate action.	A SAREX and associated Search and Rescue Seminar is being organised initially for the Bay of Bengal followed by the South China Sea areas.	On-going
C 8/29	ANC	**Carriage of ACAS and Transponders** Noted the conclusion, its relation to ANC action (147-2) on State letters AN 11/1.1.23-97/70 and AN 7/1.3.72-97/77 and encouraged States to work towards the early implementation of the conclusion.	A Regional Supplementary Procedure has been approved. Further action to be undertaken by APANPIRG/11 regarding fostering implementation by States	Completed
C 8/39	C	**CNS/ATM training workshops and seminars** Noted the conclusion	Several CNS/ATM workshops are being organised.	On-going
C 9/1	C	**Implementation of the Revised South China Sea ATS Route Structure** Noted the conclusion, its relation to APANPIRG/8 Conclusion 8/2 and the need to continue the on-going efforts of the parties with the support of ICAO to implement the revised South China Sea ATS route structure.	High level discussions continue between China and Vietnam under the auspices of ICAO	On-going
C 9/2		**Transition to WGS-84 in the ASIA/PAC Region**	ICAO Regional Office continues to undertake follow-up action with States concerned.	On-going
C 9/3	ANC	**Examine the possibility of including the Asia Region to the implementation schedule of RVSM in the Pacific Region** Noted the conclusion and its basis on capacity needs and fuel saving benefits.	The ICAO RVSM/TF is planning for and facilitating the implementation of RVSM in Asia Region. A tentative target implementation date of 21 February 2002 has been set.	On-going

Report Reference ---------------- Conc/Dec No	Action by ANC/ Council	Decision/Conclusion Title/ ANC/Council Action, if any	Action by States/ICAO	Status
C 9/6	C	**Establishment of Area Control Service and 10-Minute Longitudinal Separation using Mach Number Technique** Noted the conclusion.	Limited progress reported by States. With respect to the application of MNT, the ICAO Regional Office will progress an amendment to Doc 7030 to streamline the existing provisions	On-going
C 9/8		**ATS Route Amendments**	Some information received. Document of ATS Route Network revised and updated.	On-going
C 9/9	ANC	**Human Factor in the Provision of ATS** Noted the conclusion	First ATS Human Factors Seminar scheduled for October 2000. Very little information received from States	On-going
D 9/39		**CNS/ATM Training and Human Resource Development Task Force**	The Task Force held its first meeting in July 1999. A Regional CNS/ATM Training & Human Resource Development Strategy was developed. Further work may be progressed when the outputs of the ICAO Human Resource Planning and Training Needs Study Group become available.	On-going
D 9/47		**Contingency Planning for Y2K problems - Formation of an APANPIRG Y2K Contingency Planning Task Force**	Work successfully undertaken	Completed
C 9/51	C	**Strengthening the Regional Office resources** Noted the conclusion and requested the Secretary General to take appropriate action thereon	Secretary General has been requested to take appropriate action.	On-going

Agenda Item 3: Review and progress the tasks assigned to the ATS/AIS/SAR/SG by APANPIRG

3.1 RVSM Implementation

3.1.1 The meeting reviewed the work of the ICAO RVSM Implementation Task Force (RVSM/TF) and implementation of RVSM in the Asia Pacific Region.

3.1.2 The RVSM/TF has met four times since its establishment at APANPIRG/10:

TF/5 - Tokyo, 4-5 November 1999;
TF/5a - Honolulu, 20-22 January 2000;
TF/6 - Singapore, 10-14 April 2000; and
TF/7 - Honolulu, 17-18 April 2000

3.1.3 RVSM/TF meetings have had wide representation from States planning to implement RVSM, States considering implementing RVSM, operators, international organizations and industry groups.

3.1.4 Terms Of Reference

3.1.4.1 The meeting was advised that as the work of the RVSM/TF has progressed, it has become necessary to amend the original Terms of Reference to reflect the completion of the Pacific implementation, and the beginning of work towards implementation of RVSM in the Asia Region. Accordingly the meeting reviewed and adopted the following revised Terms of Reference for the RVSM/TF:

Decision 10/1 - Revised Terms of Reference for ICAO RVSM Implementation Task Force

i. To develop strategic, benefits-driven implementation plans (based on cost benefit studies), in concert with airspace users, for RVSM operations within selected areas and airspace of the Asia Pacific Region, ensuring inter-regional harmonization;

ii. To consider any amendments to RVSM guidance material that may be proposed by States and international organizations; and

iii. To address any other matters as appropriate and relevant to the implementation of RVSM.

iv. The Task Force will include participation from States and International Organizations that are considering or involved with the implementation of RVSM.

v. The Task Force will report to the ATS/AIS/SAR Sub-Group.

3.1.5 Pacific Implementation

3.1.5.1 The meeting recalled that RVSM was successfully implemented on 24 February 2000 at 0700 UTC between flight levels 290 and 390, inclusive, in the Tokyo, Naha, Anchorage, Oakland, Nadi, Tahiti, Honiara, Nauru, Auckland and Brisbane flight information regions (FIR). Due to communications problems, Port Moresby FIR delayed implementation until 13 April 2000 at 0700 UTC. All States agreed to use the single alternate flight level orientation scheme, in accordance with ICAO Annex 2, Appendix 3. Application of exclusive airspace varied between implementing States.

3.1.5.2 As part of the implementation process procedures for the accommodation of certain unapproved ferry or maintenance flights into exclusionary RVSM airspace were agreed, as well as procedures for the accommodation of unapproved State aircraft into exclusionary RVSM airspace.

3.1.5.3 A pre-implementation target for operational approval had been set at 90%. The last assessment by the RVSM/TF in January 2000 indicated that Anchorage, Oakland, Tokyo and Naha FIRs would meet the 90% target. The projection for the Auckland FIR was 87%, Brisbane FIR 82%, and Nadi FIR 82%. A careful examination of the unapproved operators was conducted by the RVSM/TF, including such factors as type, area of operation, and time of operation. After discounting several types of operations that were considered to have no impact on RVSM implementation, the RVSM/TF agreed that Auckland, Brisbane, and Nadi FIRs would implement based on the current approval projections. Traffic information from the Tahiti FIR indicated that an approval rate of 98%, in airspace where RVSM will be applied, had been achieved.

3.1.5.4 The RVSM/TF agreed that a mandatory pilot report upon reaching assigned altitude in other than radar or automatic dependent surveillance (ADS) coverage was necessary as an additional safeguard against pilots leveling at the wrong altitude. Wording was developed and incorporated into the appropriate aeronautical information publication (AIP) or chart supplement.

Issues relating to airworthiness and aircraft operations

3.1.5.5 Guidance was developed on contingencies during RVSM operations for use by aircraft dispatchers.

3.1.5.6 Procedures were developed and disseminated for aircraft found to be non-compliant through monitoring.

Issues relating to safety and airspace monitoring

3.1.5.7 The RVSM/TF determined the need for a regional monitoring agency and simulations that were necessary to support the safety assessment. The RVSM/TF agreed that, before RVSM implementation, it was useful to simulate the collision risk model parameter "occupancy" (a measure of aircraft passing frequency) that would be expected after RVSM implementation. Further, it was essential to have all of the approval and monitoring data in one central location in order to perform a timely assessment. A regional agency was needed to smoothly perform many of the tasks required for assessing aircraft compliance. APANPIRG/10 noted the establishment of the Asia Pacific Approvals Registry and Monitoring Organization (APARMO) as the regional monitoring agency. APARMO services continue to be provided by the United States FAA William J. Hughes Technical Center.

3.1.5.8 The RVSM/TF developed and reviewed a number of mathematical models and parameters with the objective of providing an assurance that the implementation of RVSM in the Pacific, from a collision risk perspective, was conduced safely. The areas that were addressed include:

a) a six part collision risk model relating to:
   i. aircraft pairs at adjacent altitudes and in level flight;
   ii. aircraft descending through lower flight levels during emergencies or incorrectly followed contingency procedures;
   iii. aircraft adhering to incorrect flight levels;
   iv. aircraft pairs at adjacent altitudes approaching or at intersecting routes;
   v. formation flights; and

vi. aircraft pairs at adjacent altitudes that maintain vertical alignment for an entire oceanic crossing;

b) an assessment of improved lateral performance from GPS-equipped aircraft operations in the Pacific;

c) an assessment of average Pacific aircraft height, length, and wingspan;

d) an assessment of aircraft vertical occupancy in the airspace of the Pacific;

e) an investigation into the effect of lateral offsets on the lateral collision risk estimate; and

f) the application of the collision risk model in non-exclusionary airspace.

3.1.5.9 The RVSM/TF developed minimum monitoring requirements. These requirements were designed to be consistent with the North Atlantic (NAT) while simultaneously focusing on Pacific aircraft operators without prior RVSM experience. The RVSM/TF recognized that there were two monitoring goals – short and long-term. The short-term monitoring goal was designed to support the safe introduction of RVSM. The long-term monitoring goal was designed to ensure continued safe operation of the system.

3.1.5.10 The RVSM/TF evaluated the performance of the GPS-based Monitoring System (GMS) in the coastal areas of the South Pacific as compared to its performance in the western coastal areas of North America (North Pacific).

3.1.5.11 In assessing the readiness of the fleet, the APARMO took the following actions:

1) gathered samples of traffic movements from FIRs;

2) assembled notifications of State RVSM approvals, RVSM monitoring applications and the results of operator readiness surveys; and

3) forecast the proportion of operations shown in the traffic samples as operating in airspace where RVSM will be applied, which were expected to be State approved on 24 February 2000.

3.1.5.12 The APARMO received traffic movement samples from the Brisbane, Nadi, Tokyo/Naha, Auckland and Anchorage/Oakland FIRs and that the majority covered a common period of 1 April through 30 September 1999. The samples were each processed to ensure that only commercial operations conducted from FL290 through FL390 inclusive were included.

3.1.5.13 The APARMO used the following sources of information to project operator RVSM readiness.

1) full and airworthiness State approvals communicated directly to the APARMO;

2) full and airworthiness approvals on file with the NAT Central Monitoring Agency database;

3) RVSM monitoring applications sent to the APARMO;

4) the results of a February 1999 IATA operator survey; and

5) results from an operator survey conducted on behalf of the APARMO in December 1999.

RVSM Safety Assessment

3.1.5.14 The meeting recalled that APANPIRG had adopted a Target Level of Safety (TLS) value of 5×10^{-9} fatal accidents per flying hour as the safety goal to be satisfied as prerequisite for Pacific RVSM implementation. The TLS value of 5×10^{-9} fatal accidents per flying hour was the upper bound on the risk of collision in the vertical plane due to all causes after RVSM implementation. In addition to satisfying this overall TLS value, it was also be necessary that the risk of collision due to correctly established 1000-ft vertical separation not exceed 2.5×10^{-9} fatal accidents per flying hour. The term "technical risk" was adopted to describe this component of overall vertical collision risk, which is associated with the height keeping performance of State RVSM-approved aircraft. Based on experience with RVSM application in the North Atlantic, it was expected that the overall vertical collision risk would be strongly influenced by the frequency of operational errors in Pacific airspace where the RVSM would be applied.

3.1.5.15 The APARMO assembled information from several sources in order to estimate both the technical and overall collision risk that would pertain after Pacific RVSM implementation, assessed monitoring results from the Pacific, and concluded that, as anticipated, they were consistent with those available from NAT RVSM application. As a result, both were used in assessing technical risk. In addition, Pacific reports of turbulence-induced large height deviations and vertical displacements due to TCAS resolution advisories were employed in developing an estimate of technical risk.

3.1.5.16 Estimation of overall collision risk associated with RVSM implementation was aided by archived reports of large height deviations provided by the Airways Corporation of New Zealand, Airservices Australia and the FAA's Anchorage and Oakland oceanic centers. These organizations, as well as the Japan Civil Aviation Bureau and Airports Fiji Limited, informed the APARMO that there had been no instances of large height deviations since October 1999 in the portions of Pacific airspace under their respective control. The APARMO also made use of information concerning Pacific large height deviations uncovered in several aviation safety databases.

3.1.5.17 The APARMO produced a single assessment of safety associated with Pacific RVSM implementation. In so doing, the APARMO made estimates of technical and overall risk for sub-regions of the Pacific and then combined them into single values. As an aid to this process, the APARMO examined traffic samples provided by ATS providers as part of the readiness assessment. The examination indicated that roughly 82 percent of Pacific flight time between FL290 and FL390 -- estimated to be about 1 million flight hours per year -- was accounted for by operations conducted in airspace north of Hawaii, with the remaining 18 percent to the south.

3.1.5.18 The risk attributable to aircraft technical height keeping performance - traceable to performance of aircraft altimetry and altitude keeping systems, as well as the effects of turbulence- and TCAS-induced large height deviations - fell below the TLS value agreed for safety assessment of this source of risk. The APARMO's composite-Pacific estimate of this risk was roughly 0.2×10^{-9} fatal accidents per flight hour, or about a factor of 15 less than the TLS value of 2.5×10^{-9} fatal accidents per flying hour agreed as the appropriate safety criterion. The RVSM/TF acknowledged the influence of large height deviations, particularly those resulting in sustained aircraft operation at other than cleared flight level, upon risk. The APARMO noted that such occurrences had considerable influence on its estimate of risk due to all causes. The APARMO informed the RVSM/TF that its estimate of overall risk due in the Pacific to all causes was 4.51×10^{-9} fatal accidents per flying hour, below the TLS value of 5×10^{-9} fatal accidents per flying hour agreed for use in assessing its acceptability. Both of these estimates demonstrated that the safety goal for technical risk had been met. Subsequent to the Task Force meeting, several States jointly reviewed the circumstances of the large height deviations which they reported in their airspaces. This resulted in a reallocation of times spent at other than cleared flight level within sub-regions of the Pacific. An estimation of risk based upon this reallocation also showed that the overall safety goal of 5×10^{-9} was still met.

3.1.5.19 The RVSM/TF considered concerns expressed by a representative of the International Federation of Air Line Pilots Associations (IFALPA) relating to aircraft flying on the same route in opposite directions at adjacent RVSM flight levels. Although IFALPA had not developed a formal position on the matter, concern was growing within its membership as the result of recent clarification of flight level orientation schemes to be used in some areas of the Pacific after RVSM implementation. The IFALPA concerns were based on the operational judgment that opposite-direction aircraft pairs at adjacent RVSM flight levels would present possible wake turbulence and TCAS alert threats to each other. Furthermore, any instance of an operational error involving such a pair would be less easily resolved due to the high relative speeds involved coupled with the lack of broad-area surveillance and rapid communication links. It was reported that the ICAO Review of the General Concept of Separation Panel (RGCSP) was working to formalize the use of lateral offsets as a strategic means of decreasing risk and related factors in RVSM airspace. The IFALPA representative noted this development with satisfaction and expressed the view that such offsets would likely mitigate the growing IFALPA concerns.

Post-Implementation Review

3.1.5.20 The RVSM/TF met on 17-18 April 2000 in Honolulu to review the Pacific implementation and address any problems that had been identified. In general, the implementation was successful and the use of RVSM is reported as being operationally beneficial. Several specific items were identified that generated discussion and merited further action.

3.1.5.21 At the RVSM/TF meeting it was suggested that an operational benefit would be gained by allowing the use of RVSM up to FL 410. The RVSM/TF agreed that this expansion should not be exclusionary in nature, that is the altitudes between FL 390 and FL 410 would be a mixed-equipage environment. The target date for this expansion is 5 October 2000.

3.1.5.22 Development of a post-implementation monitoring program is in progress.

3.1.6 Asia Implementation

3.1.6.1 The Sixth Meeting of the RVSM/TF focused on plans for implementation of RVSM in the Western Pacific/South China Sea. Preliminary discussions indicate a target implementation date of 21 February 2002. It became evident at that meeting that the representatives wished to consider not only the Western Pacific/South China Sea area, but rather to expand consideration to the major traffic flows in southeast Asia and from Asia to Europe south of the Himalayas.

Operational implementation

3.1.6.3 The RVSM/TF reviewed the principles for the planning and implementation of RVSM with regard to the application of the Flight Level Orientation Scheme, usable band of RVSM levels, exclusion of non-approved aircraft and special provisions for State and ferry/maintenance aircraft, and outlined a provisional plan for the implementation of RVSM in the Western Pacific/South China Sea area. Preliminary interest in implementing RVSM on 21 February 2002 was expressed by representatives from the Bangkok, Hong Kong, Jakarta, Kota Kinabalu, Kuala Lumpur, Manila, Phnom Penh, Singapore, Ujung Pandang, and Vientiane FIRs. This plan will be further refined at the next meeting of the RVSM/TF. Initial discussions have taken place regarding issues relating to airworthiness and aircraft operations, and safety and airspace monitoring.

Safety and Airspace Monitoring

3.1.6.4 Two principal tasks would be required in connection with RVSM implementation: (1) an assessment of the readiness of operators and aircraft, as reflected in the proportion of operations which would be conducted by State-approved operators and aircraft in the airspace where RVSM will be introduced and (2) an assessment of the safety of RVSM implementation. In light of Pacific RVSM implementation experience, it would not be possible to conduct a readiness assessment until the date for RVSM implementation was more proximate.

3.1.6.5 The RVSM/TF noted the importance of information concerning large height deviations in conducting a comprehensive safety assessment. The ICAO Asia and Pacific Regional Office issued State Letter T 3/10.1.7-AP-ATM0586 on 23 September 1998, which requested that States, operators and flight crews report instances of large height deviations within Pacific airspace where the RVSM would be applied. A companion International NOTAM requested the same information. Both documents contained as an attachment a form that detailed the information required and specified the APARMO as its recipient.

3.1.7 RVSM Implementation Plan Status Report

3.1.7.1 The RVSM/TF continued to review the status of the RVSM Implementation Plan for the Asia Pacific Region. The updated Asia/Pacific Region RVSM Implementation Plans Status Report is shown in Appendix A to the Report on Agenda Item 3.

3.1.8 Future Work

3.1.8.1 The following tentative schedule of TF meetings has been agreed:

RVSM TF/8: Hong Kong, 28 August - 1 September 2000 (Asia focus)
RVSM TF/9: January 2001 (Asia focus)
RVSM TF/10: Honolulu, February 2001 (Pacific Review focus)
RVSM Seminar: February 2001 (Asia focus)
RVSM TF/11: May 2001 (Asia focus)
RVSM TF/12: August 2001 (Asia focus)
RVSM TF/13: December 2001 (Asia focus)

3.1.8.2 IATA advised the meeting that it considered the implementation of RVSM in the Pacific to be a great success and that it hoped the implementation in Asia could be co-ordinated with the European implementation through the Middle East to provide an end-to-end Asia/Europe RVSM environment.

3.1.9 RVSM Implementation Guidance Material

3.1.9.1 The meeting recalled that the *Guidance Material on the Implementation of a 300 m (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Pacific Region* was initially adopted by APANPIRG/9, with a subsequent amendment adopted by APANPIRG/10.

3.1.9.2 In light of the plans to progress the implementation of RVSM into Asia, the meeting was advised that the RVSM/TF had undertaken work to expand the existing Pacific guidance material to become applicable to the whole Asia Pacific Region.

3.1.9.3 In addition the opportunity was taken to update the guidance material to add a phraseology for use by the pilot to notify ATC of an equipment failure rendering the aircraft no longer capable of meeting the requirements for operation in airspace designated for RVSM operations.

3.1.9.4 The meeting developed the following Draft Conclusion:

Draft Conclusion 10/2 - Guidance Material on the Implementation of a 300 m (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Asia Pacific Region

That the *Guidance Material on the Implementation of a 300 m (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Asia Pacific Region* which is contained at Appendix B to the Report on Agenda Item 3 be adopted as RVSM implementation guidance material for the Asia Pacific Region.

3.1.9.5 The meeting passed its appreciation and thanks for the work carried out to date by the RVSM/TF.

3.2 **Implementation of WGS-84**

3.2.1 The meeting recalled that amendments to Annex 4, Annex 11, Annex14 (Parts 1 & 2) and Annex 15, adopted in early 1994, introduced the World Geodetic System 1984 (WGS-84) as the world-wide common geodetic reference datum. The amendments to these Annexes required all States to publish their relevant aeronautical data in WGS-84 on (or before) 1 January 1998.

3.2.2 In order to maintain a current status of WGS-84 implementation in the Asia Pacific Region the meeting reviewed and updated the WGS-84 Implementation Survey. The updated WGS-84 Implementation Survey is at Appendix C to the Report on Agenda Item 3.

3.2.3 The meeting was advised that States should clearly indicate in their AIP if the transformation to WGS-84 has been undertaken. It was noted that many airlines required this information prior to be able to navigate by GNSS.

3.3 **Asia Pacific Regional CNS/ATM Guidance Material**

3.3.1 The meeting recalled that Item Number 19 of the ATS/AIS/SAR Sub-group Subject Task List relates to the maintenance of the Asia Pacific Regional CNS/ATM Guidance Material (CNS/ATM/GM). The Action Proposed for the Sub-group is to:

a) Update the Guidance Material as required, and;

b) Develop a "Concept of Operations" for application in an initial ADS environment".

3.3.2 The meeting was advised that the most recent meeting of the Informal South Pacific ATS Co-ordination Group (ISPACG), which was held in Brisbane 6-10 December 1999, discussed the growing need within the Asia Pacific Region, due to the increasing number of participating ATS units and operators, for common CNS/ATM operational ATS and pilot documentation. ISPACG noted that the ICAO CNS/ATM/GM was available as common guidance material but that it did not contain operational ATS and pilot procedures such as are detailed in the South Pacific Operations Manual (SPOM).

3.3.3 In the interests of standardization, it was suggested by ISPACG that the SPOM and the ICAO CNS/ATM/GM should be jointly reviewed with the objectives of:

a) realigning and updating the ICAO CNS/ATM/GM to provide core guidance material and a framework for State CNS/ATM Operations Manuals; and

b) reissuing the SPOM as a joint South Pacific CNS/ATM Operations Manual.

3.3.4 Under this scenario, the ICAO CNS/ATM/GM would provide a base publication from which States could publish operational ATS and pilot procedure supplements in accordance with their particular major geographic traffic flows. The reissued SPOM could also serve as a model State CNS/ATM Operations Manual for other groups of implementing States. Accordingly, ISPACG requested ICAO to facilitate a small group of experts to achieve this task.

3.3.5 A meeting of a small group of experts took place 5-6 March in Melbourne following which work has been undertaken by correspondence. It was hoped to have a revised version of the CNS/ATM/GM available for review by the ATS/AIS/SAR/SG/10 meeting. The meeting was advised that there is still some work to be completed before the CNS/ATM/GM will be available.

3.3.6 Accordingly the meeting noted the fact that the CNS/ATM/GM is currently the subject of a major review. In recognition of the fact that timely publication of the revised CNS/ATM/GM is required, the meeting requested the secretariat to request the CNS/ATM/IC Subgroup to review the revised draft for onward submission to APANPIRG/11.

3.4 Analysis of SAR Capability of ICAO States in the ASIA/PAC Region

3.4.1 The meeting reviewed the table titled Analysis of SAR Capability of ICAO States in the ASIA/PAC Region and updated the information as described in Appendix D to the Report on Agenda Item 3.

3.4.2 The meeting was reminded that, in accordance with APANPIRG Conclusion 7/3 States were required to provide information to ICAO by 30 April of each year to permit periodic update. There has been little response to this request, the meeting formed the following draft conclusion:

Draft Conclusion 10/3 – SAR Capability Matrix

That, the “SAR Capability Matrix” be distributed to States for information and action as appropriate, and States be requested to provide information to ICAO by 30 April 2001 to permit the periodic update of the Matrix.

<u>Provision of SAR and SAR Agreements</u>

3.4.3 The meeting noted that APANPIRG/6 Conclusion 6/13 on SAR Agreements stated:

a) States are encouraged to develop formal SAR agreements on bi-lateral or multi-lateral basis; and,

b) ICAO establish and maintain a register of SAR agreements between States.

3.4.4 Very few of the States, which have established such SAR agreements, have forwarded material to ICAO and as such, the register has not yet been established. In order to achieve a co-ordinated response to search and rescue situations, States were urged to complete their SAR agreements with their neighbouring States and forward such agreements to the ICAO office so that a register on SAR Agreements can be established.

<u>SAR Exercises</u>

3.4.5 The meeting was advised that some States hold regular joint SAR exercises (SAREXs) with their neighbours which have proved to be productive in the standardization of their procedures. States were encouraged to continue this practice or where these joint SAREXs are not presently taking place, make appropriate arrangements to develop and initiate these exercises. The meeting was also advised that many States hold regular local SAREXs. They were encouraged to continue this procedure to build confidence in their SAR system.

3.4.6 The meeting noted that it is proposed to hold an International Search and Rescue Seminar and SAREX involving some States of the Bay of Bengal area in the first quarter of 2001. This seminar and SAREX was initially planned for last year but due to the work associated with the Y2K programme, it was necessary to defer this item. All ASIA/PAC States plus concerned aviation organizations will be invited to this International SAR Seminar and SAREX.

Search and Rescue Training

3.4.7 The meeting was advised that ICAO, in partnership with the International Maritime Organization (IMO), has developed an International Aeronautical and Maritime Search and Rescue Manual (Doc 9731-AN/958). The first edition of this Manual, which is in three volumes was distributed to all States in 1999.

3.4.8 The manuals give a comprehensive explanation of search and rescue responsibilities and requirements and are designed to assist States in meeting their own search and rescue needs and the obligation they accepted under the Convention on International Civil Aviation, the International Convention on Maritime Search and Rescue and the International Convention for the Safety of Life at Sea (SOLAS) These volumes provide guidelines for a common aviation and maritime approach to organizing and providing SAR services.

3.4.9 Using these guidelines, States are encouraged to develop and improve their SAR services, cooperate with neighbouring States and to consider their SAR services to be part of a global system.

3.4.10 Of particular interest regarding the training of SAR personnel, the meeting was advised that Chapter 3 of the Manual considered the use of training, qualification and certification processes to develop professionally competent SAR personnel. A number of aspects of training and of exercises used for training, are examined in detail in the manual.

3.5 Implementation of ACAS II

3.5.1 The meeting recalled that on 12 January 2000 the President on behalf of the ICAO Council approved an amendment to the Regional Supplementary Procedures (Doc 7030) (Serial No. APAC-S 98/4 - ASIA/PAC RAC) relating to the carriage of pressure-altitude reporting transponders and ACAS II. The provisions of Doc 7030 became applicable on 23 March 2000 and were incorporated into Amendment No. 196 (13 February 2000) to the MID/ASIA and PAC Regional Supplementary Procedures.

3.5.2 Paragraph 8.1.1 a) of the PAC and MID/ASIA Regional Supplementary Procedures (Doc 7030) calls for specified aircraft to be equipped with ACAS II by 1 January 2000. It states that turbine-powered aircraft that have a take-off mass of more than 15,000 kg (33,000 pounds) or that are authorized to carry more than 30 passengers shall be equipped by that date.

3.5.3 The meeting was advised that the vast majority of aircraft that are equipped with a "traffic alert and collision avoidance system" (TCAS) are currently equipped with TCAS II, Version

6.04. To be considered fully compliant with ICAO SARP functionality for ACAS II, TCAS II must be upgraded to TCAS II, Change 7. The avionics manufacturers were not able to make the Change 7 modification package available to operators until the first quarter of this year. Only a small percentage of aircraft that are required to be ACAS II equipped are currently equipped with Change 7.

3.5.4 In discussing this issue the meeting noted the critical importance of aircraft not equipped with a pressure altitude reporting transponders not being permitted to share airspace used by aircraft equipped with airborne collision avoidance systems. The performance of ACAS is totally dependent on all aircraft in the vicinity being equipped with pressure altitude reporting transponders, in order to detect conflicting traffic and offer resolution advisories. Therefore the meeting saw an urgent need to bring to the attention of States the need implement regulations for the mandatory carriage and operation of pressure altitude reporting transponders without any further delay. Accordingly the meeting developed the following Draft Conclusion:

Draft Conclusion 10/4 – Mandatory Carriage & Operation of Pressure Altitude Reporting Transponders

That, States take immediate steps to mandate the carriage and operation of pressure altitude reporting transponders within all FIRs in the Asia Pacific Region.

3.5.5 The meeting recalled again that the lack of availability of ACAS II equipment has made the Doc7030 provisions impossible to implement on time. Furthermore it is apparent that some States in the Asia Pacific Region are not planning to mandate the carriage of ACAS until the globally agreed date of 1 January 2003.

3.5.6 Noting the need to encourage the carriage and operation of ACAS II by aircraft operating in the Asia Pacific Region, the meeting developed the following Draft Conclusion:

Draft Conclusion 10/5 – Implementation of ACAS II

That States;

a) Be requested to promulgate their implementation plans mandating the carriage and operation of ACAS II; and

b) Where this is in advance of the globally agreed date of 1 January 2003 to provide for the continuing use of TCAS with version 6.04A logic with a transition plan to phase out systems with version 6.04A logic by 1 January 2002.

3.5.7 The meeting reviewed the results of a survey undertaken by the Regional Office to seek the implementation plans of States in the Region with respect to the carriage of ACAS and Pressure Altitude Reporting Transponders. The results of the survey are contained at Appendix E to the Report on Agenda Item 3. The meeting was advised that it was the intention of the Secretariat to expand the survey in order to obtain additional and more specific information, namely information regarding:

1. those States who have already mandated the carriage and operation of pressure-altitude reporting transponders;

2. those States who plan to mandate the carriage and operation of pressure-altitude reporting transponders and the planned date of implementation;

3. those States who have already mandated the carriage and operation of ACAS, and who have accepted TCAS V6.04 as meeting their requirements and the transition period to the ACAS II compliant TCAS Change 7; and

4. those States who plan to mandate the carriage and operation of ACAS, and the planned date of implementation.

3.5.8 The meeting was reminded that when States are planning the implementation of ACAS II with respect to specific portions of airspace, consideration should be given to the needs of State aircraft.

3.6 **SSR Code Management in Asia/Pacific**

3.6.1 The meeting was advised that the Australian automated ATS system was working towards enhanced international harmonization with respect to Mode3/A SSR code management. As a result of this action, the Australian system will be able to retain and use the SSR code assigned by the relevant ATS unit at the departure point to international flights inbound or planning to overfly the Australian FIR.

3.6.2 Retention of the SSR code assigned at the point of departure is consistent with ICAO principles contained in the Regional Supplementary Procedures, Doc 7030/4, to ensure that a code assigned to an aircraft is retained for the duration of its flight from departure point to the destination, and that code changes should only be undertaken to meet the essential needs of ATC in the receiving FIR. In this regard, Regional code allotments have been chosen in such a way as to maximize uniqueness that will support retention.

3.6.3 Prior to, and during the transition to the automated system in Australia, multi-system complexities precluded retention of SSR codes in the Australian FIR, consequently international flights entering the Australian FIR were required to change to an Australian domestic code on entry.

3.6.4 The meeting was also advised that, in respect of SSR code management, other issues had arisen that were not compliant with the requirements of Doc 7030/4 and PANS-RAC Doc 4444.

3.6.5 These issues related to the absence of SSR codes in DEP messages sent from some States, and an apparent practice of having flights change to code 2000 when leaving a FIR. In this regard, Australia sought the assistance and cooperation of States to ensure that DEP messages contained the appropriate SSR code information, and that flights retained their assigned SSR code from departure point to destination to the greatest extent possible, and without changes to code 2000 for exiting flights.

3.6.6 A further matter was raised during the discussions relating to the management of SSR codes in the Asia/Pacific Region. This was associated with the early notification of changes to the allocation of codes in the Region. Automation of ATC systems across the Region means that timely notification of changes to the allocation of SSR code blocks is essential so that States can make any alterations to their systems before the changes are introduced and thus avoid any conflicts with codes that might have been allocated for use elsewhere within the Region, for example domestic operations.

3.6.7 The meeting recognized the inherent dangers of code duplication, or the unnecessary assignment of code 2000 for flights exiting a FIR.

3.6.8 As a result of the discussions on SSR code management in the Asia/Pacific Region, the meeting noted the issues that had been raised by Australia, and agreed:

a) to ensure that the assigned SSR code be included in all departure messages for international flights; and

b) to retain and use the SSR code assigned on departure to international flights for the duration of the flight, as far as possible in accordance with PANS-RAC and the Regional SSR Code Management Plan.

3.6.9 The meeting further agreed that the ICAO Asia/Pacific Office should continue to facilitate timely advice to States regarding changes to the Regional SSR code allotments.

3.6.10 With regard to the Asia/Pacific SSR Code Management Plan, the meeting was advised that the draft ASIA/PAC Basic ANP and FASID had been distributed to States by the ICAO Asia/Pacific Regional Office under State Letter AP-AGA0056 dated 23 May 2000.

3.6.11 The CMP Code Allotment Table has been included as Part V – ATM of the draft FASID, however, editorial amendments to the CMP (paragraphs 4.3 and 5.3) have not been incorporated into the Draft FASID. The Secretariat will take appropriate action to amend the draft before the new ASIA/PAC Basic ANP and FASID is formally published.

3.6.12 An amendment to paragraph 4.3.1 of the CMP will also be included to better describe international flights as:

For the purpose of the CMP, a flight from one FIR to another within the boundaries of the same State should not be descried as international flight.

3.6.13 With regard to the earlier request from Myanmar for additional codes allotment, AIP Myanmar issued on 1 January 2000 revealed that Myanmar has established a new SSR code assignment, and ICAO has been in contact with Myanmar to find suitable codes to be used by Yangon FIR.

3.6.14 Concerning requests for additional SSR Code Allotment from other States, there has been no request forwarded to the Regional Office.

3.7 Mach Number Technique (MNT) and Required Navigation Performance (RNP)

3.7.1 The meeting spent some time discussing the current application of Mach Number Technique (MNT) and the intended implementation of Required Navigation Performance (RNP) in Asia. It was noted that many States in the South China Sea area have, for quite a few years, adopted the Australian AUSEP criteria as the means to identify those aircraft that have area navigation systems that meet the requirements for the application of reduced longitudinal separation based on MNT. It was recognized that the use of AUSEP creates confusion with some pilots who are not familiar with this criteria.

3.7.2 The meeting saw benefit in removing the use of AUSEP and moving to an implementation of RNP-10. This would, apart from continuing to provide a suitable means to identify aircraft for the application of MNT, provide additional air traffic management enhancements. It was recognized that further work, on a sub-regional basis, would be undertaken regarding this matter.

3.8 Implementation of ATS routes

3.8.1 The Sub-group noted that in accordance with the uniform methodology for the identification, assessment and reporting of shortcomings and deficiencies approved by Council on 23 June 1998, a situation where a facility is not installed or a service is not provided in accordance with a regional ANP is considered to be a **shortcoming**, whilst a situation where an existing facility or service is partially unserviceable or not operated in accordance with appropriate ICAO specifications and procedures is considered to be a **deficiency**.

3.8.2 The meeting recalled the APANPIRG/9 Conclusion 9/8 – ATS Route Amendments which specifies: *It is reiterated that, States should provide information regarding implemented, re-aligned or deleted ATS routes to ICAO by 30 April of each year in order to permit the periodic update of the Document of ATS Route Network*.

3.8.3 It was noted that in a follow-up to APANPIRG Conclusion 9/8, China, India, Indonesia, Japan, Malaysia, Papua New Guinea, Singapore, Thailand, and the United States have provided information including the action agreed to be taken by States concerned. Based on that information and information derived from AIS materials from States, an updated list of ATS routes which had not been implemented, including ATS routes which had been implemented, but not in accordance with ANP requirements, with information concerning appropriate action proposed and /or being taken by States concerned was presented to the meeting for review and further update.

3.8.4 The meeting noted that ANP amendment proposal APAC 95/16-ATS (new ATS route structure across the South China Sea) was approved by the President of the Council on 7 May 1997. This amendment deleted or amended most of the existing ATS routes and introduced a system of RNAV routes. As such, the ANP no longer lists the requirement for the existing route network, which will however be in place until such time as the new route structure is implemented. The updated list did not include routes associated with APAC 95/16-ATS. Also noted was that ATS route amendments approved after AIRAC date 18 May 2000 were not included in this updated list.

3.8.5 The meeting reviewed the updated list of ATS routes which had not been implemented, and further updated the list taking into account information provided at the meeting from States concerning the latest status of implementation and/or action being taken. This updated list of ATS routes is attached to Appendix F to the report on Agenda Item 3.

3.8.6 The meeting identified shortcomings and deficiencies related to ATS route network in the Asia/Pacific Region, and considered inclusion of those non-implemented ATS routes as shortcomings in the list of air navigation shortcomings and deficiencies.

3.9 Inclusion of SIGMET in VOLMET broadcasts in the Asia/Pacific Region

3.9.1 The meeting recalled that IATA and IFALPA had been invited to carry out a survey among its member airlines operating in the Asia Region concerning requirements for inclusion of SIGMET in VOLMET broadcasts.

3.9.2 At APANPIRG/10, IATA advised that a majority of airlines concerned supported the inclusion of SIGMET in VOLMET broadcasts. Airlines who did not lend support to the inclusion of SIGMET in VOLMET broadcasts were either airlines with MET datalink service through SITA or airlines who were concerned that including SIGMET in VOLMET broadcasts would relieve ATS of its obligations under PANS-RAC.

3.9.3 It was also advised that IFALPA supported the inclusion of SIGMET in VOLMET broadcasts, provided that the inclusion of all SIGMET would not disrupt the VOLMET broadcast schedule.

3.9.4 Advice was provided that ICAO Annex 3-*Meteorological Services for International Air Navigation*, Section 11 recommends that SIGMET messages should be included in scheduled VOLMET broadcasts if determined by regional air navigation agreement. Where this is done the SIGMET message or an indication of a "NIL SIGMET" should be transmitted at the beginning of the broadcast within the five-minute time block.

3.9.5 APANPIRG/10 considered the information provided by IATA and IFALPA, and formulated Conclusion 10/3 - ANP Amendment Proposal to include SIGMET in VOLMET Broadcasts (ASIA), which specifies: *the ASIA/PAC Air Navigation Plan (Doc 9673) be amended to add a requirement for inclusion of SIGMET in VOLMET broadcasts for the Asia Region.*

3.9.6 The meeting was informed that in pursuit of APANPIRG Conclusion 10/3, the Secretariat drafted an amendment proposal to the Asia/Pacific ANP (Serial number APAC 99/9-ATS). The draft proposal was forwarded to the following States whose facility and services will be significantly affected by the proposal, for comments before it would be formally circulated to all concerned:

Australia	China	Hong Kong, China	India
Japan	New Zealand	Pakistan	Singapore
Thailand			

3.9.7 The meeting was advised that Hong Kong/China, India, Pakistan, Singapore, and Thailand expressed concurrence or no objection to the proposal, without specific comments.

3.9.8 It was also noted that Australia, China and Japan expressed concerns regarding the limited time for broadcast though they were all in favour of the proposal in principle. In this context, Australia proposed that SIGMET information or its availability be included in VOLMET broadcasts as the final section, when time permits. Japan addressed a few technical issues to be determined by the regional agreement as follows:

i) the allocation of SIGMET transmission among VOLMET broadcast stations needs to be considered (under the current arrangements, SIGMET for Naha FIR will not be transmitted by Tokyo VOLMET broadcast);

ii) the format of SIGMET to be transmitted needs to be considered (full text or title only); and

iii) the possibility of partial deletion of current METAR and TAF transmitting stations and/or changes of their broadcast schedule.

3.9.9 New Zealand raised an objection to the proposal. Auckland broadcast includes TAF, METAR and TTL for designated aerodromes in accordance with the present ANP. The existence and validity of SIGMET is also included. However inclusion of full SIGMET is not considered possible simply because of the limitation of broadcast time.

3.9.10 The meeting was advised that the existing Asia/Pacific ANP does not address a requirement for inclusion of SIGMET in VOLMET broadcasts by Tokyo, Hong Kong and Auckland for the Pacific Region. Therefore, it is suggested that the amendment proposal be modified to properly reflect the requirements for the Asia and Pacific Regions.

3.9.11 Noting the problems expected by States, IATA emphasized the needs of full SIGMET information, not partial, in order that pilots are able to make an appropriate decision in a timely manner during flights. In addition, IATA stated that meteorological information is accessible via other means, such as datalink, these days but this is not always the case.

3.9.12 The meeting was briefed on the recent activities relating to MET datalink applications in ICAO, and noted that any emerging technological developments in communication systems will not provide immediate solutions to this particular issue. Availability of additional frequencies for VOLMET broadcast in the ASIA/PAC Region was also sought; however it was considered not to be an immediate solution, either, due to a lengthy period anticipated for co-ordination at a global level.

3.9.13 Discussions varied from inclusion of full SIGMET information or partial information, such as a notification of SIGMET.

3.9.14 The Secretariat provided information concerning procedures being applied for VOLMET broadcast including SIGMET in the North Atlantic (NAT) Region. In the NAT Region, SIGMET information included in the Gander broadcasts include SIGMET or notification of SIGMET affecting flights operating above FL100 in the Gander Oceanic and Gander, Moncton, Montreal and Toronto FIRs. Also the reports and forecast at certain aerodromes shown in brackets may be deleted from the Gander broadcasts to provide broadcasting time for the inclusion of SIGMET messages (NAT ANP, Table ATS 2 refers).

3.9.15 Noting the procedures in the NAT Region, it was felt that those service provider States might have difficulties in determining such aerodromes whose MET information can be omitted from the broadcasts when there is not sufficient time if the similar procedures are introduced in the ASIA/PAC Region, too.

3.9.16 IATA stated that the most important aspect of inclusion of SIGMET in VOLMET broadcasts is to enable pilots to have access to the necessary MET information.

3.9.17 The meeting recognized that operational needs and requirements of users should be considered with priority.

3.9.18 Finally, there was a general consensus that IATA would seek its member airlines' preference and select aerodromes, MET information of which may be omitted from VOLMET broadcasts if full SIGMET information is included in the broadcast. Then IATA will report to the Regional Office as soon as possible so that the Secretariat will modify the amendment proposal, reflecting the users' requirements and consult with States whose facility and services will be significantly affected by the proposal, for comments prior to formally circulating the proposal to all concerned in accordance with established procedures.

3.10 Report On Bay Of Bengal Task Force Progress

3.10.1 The meeting recalled that the first meeting of the Bay of Bengal Task Force took place at the ICAO Regional Office in Bangkok on 3-5 November 1997. The purpose of the meeting was to review the current Bay of Bengal ATS route structure, develop proposals for a new route structure and develop an implementation plan for the revised route structure in the area.

3.10.2 The Task Force was of the view that the basic ATS route structure across the Bay of Bengal was reasonable, but required a few modifications and additions to improve the overall traffic flow expected over the next few years.

3.10.3 The meeting further recalled that a second Task Force meeting was scheduled for 3-5 August 1998, however due to a poor attendance response from States, it was cancelled.

3.10.4 In the light of new initiatives being undertaken which look at the ATS routes system over the Bay of Bengal and extending westwards to Europe and the Middle East, the meeting considered that the Bay of Bengal Task Force should be dissolved.

3.10.5 The meeting therefore developed the following Decision:

Decision 10/6 - Dissolve the Bay of Bengal Task Force

That, in the light of new initiatives being undertaken which look at the ATS routes system over the Bay of Bengal and extending westwards to Europe and the Middle East, the Bay of Bengal Task Force is dissolved.

ASIA PACIFIC REGION RVSM IMPLEMENTATION PLANS STATUS REPORT

FIR	RVSM Implementation Date	Comments
Anchorage Arctic	24 Feb 2000	RVSM Transition Airspace only
Anchorage Continental	24 Feb 2000	RVSM Transition Airspace only
Anchorage Oceanic	24 Feb 2000	
Auckland Oceanic	24 Feb 2000	
Bali	Not applicable	Subject to Indonesia upper airspace consolidation
Bangkok	21 Feb 2002	
Beijing		
Biak	Not applicable	Subject to Indonesia upper airspace consolidation
Bombay		
Brisbane	24 Feb 2000	Oceanic East of Australia 24 Feb 2000 Remainder of FIR March 2001
Calcutta		
Colombo		
Dhaka		
Delhi		
Guangzhou		
Hanoi	To be determined	
Ho-Chi-Minh	To be determined	
Hong Kong	21 Feb 2002	
Honiara	24 Feb 2000	
Jakarta	21 Feb 2002	
Karachi		
Kathmandu		
Kota Kinabalu	21 Feb 2002	

FIR	RVSM Implementation Date	Comments
Kuala Lumpur	21 Feb 2002	
Kunming		
Lahore		
Lanzhou		
Madras		
Male		
Manila	21 Feb 2002	
Melbourne	March 2001	
Nadi	24 Feb 2000	
Naha (Pacific Oceanic)	24 Feb 2000	Non-exclusive RVSM airspace. Further phased implementation planned.
Nauru	24 Feb 2000	
New Zealand (Domestic)	13 July 2000	Non-exclusive
Oakland Oceanic	24 Feb 2000	
Phnom-Penh		
Port Moresby	13 Apr 2000	
Pyongyang		
Shanghai		
Shenyang		
Singapore	21 Feb 2002	
Taegu		
Tahiti	24 Feb 2000	Non-exclusive RVSM airspace
Taibei		
Tokyo	24 Feb 2000	Oceanic
Ujung Pandang	21 Feb 2002	

FIR	RVSM Implementation Date	Comments
Ulan Bator		
Urumqi		
Vientiane		
Wuhan		
Yangon		

THE GUIDANCE MATERIAL

ON

THE IMPLEMENTATION OF A 300 M (1000 FT) VERTICAL SEPARATION MINIMUM (VSM) FOR APPLICATION IN THE AIRSPACE OF THE ASIA PACIFIC REGION

Foreword

This document is intended to provide guidance for operators and service providers in preparation for the implementation of RVSM in the Asia Pacific Region. It takes into account the result of years of international study and analysis, and reflects both the international safety standards developed by the Review of the General Concept of Separation Panel (RGCSP), and the experience gained in other regional implementations. ICAO Doc 9574, *Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive;* and North Atlantic (NAT) Doc 002, *Guidance Material on the Implementation of a 300 m (1000 ft) Vertical Separation Minimum in the Minimum Navigation Performance Specifications Airspace of the North Atlantic Region*, provided mature source material for this document.

This document was developed by ATS authorities, airworthiness experts, and ~~Pacific~~ airspace users in the Asia Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) RVSM Implementation Task Force. It contains a brief history of the development of ICAO guidance material; and provides guidance on aircraft and operator approvals, air traffic services and flight crew requirements and procedures, and airspace monitoring in an RVSM environment.

It is hoped that the publication of this guidance material will assist in preparation for the implementation of RVSM by providing the needed information for airspace users to obtain approval, and for ATS authorities to make appropriate procedural and automation changes in a timely manner.

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LIST OF ACRONYMS

AAD	assigned altitude deviation
AKD	altitude-keeping device
APANPIRG	Asia Pacific Air Navigation Planning and Implementation Regional Group
APARMO	Asia Pacific Approvals Registry and Monitoring Organization
ASE	altimetry system error
ATC	air traffic control
ATS	air traffic services
CFL	cleared flight level
CMA	central monitoring agency
CRM	collision risk model
FL	flight level
FTE	flight technical error
GMS	global positioning system monitoring system
GMU	global positioning system monitoring unit
GNE	gross navigational error
GPS	global positioning system
HMU	height monitoring unit
ICAO	International Civil Aviation Organization
in. Hg	inches of Mercury
JAA	Joint Airworthiness Authorities
MASPS	minimum aircraft system performance specification
NAT	North Atlantic
NAT SPG	North Atlantic Systems Planning Group
OTS	organized track system
PAC	Pacific
~~PARMO~~	~~Pacific Approvals Registry and Monitoring Organization~~
PEC	position error correction
$P_y(0)$	lateral overlap probability for aircraft on the same route (i.e., no lateral distance planned between aircraft on the same route)
$P_z(1000)$	vertical overlap probability for aircraft with 1000 ft planned separation between flight levels
RGCSP	Review of the General Concept of Separation Panel
RPG	Regional Planning Group
RVSM	reduced vertical separation minimum of (300m) 1000 ft between flight levels
SD	standard deviation
SDB	State database
SSEC	static source error correction
SSR	secondary surveillance radar
TLS	target level of safety
TVE	total vertical error
VSM	vertical separation minimum

LIST OF DEFINITIONS

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

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

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

Altimetry system error distribution.
The distribution of an aggregate of altimetry system errors.

Assigned altitude deviation (AAD).
The difference between the transponded Mode C altitude and the assigned altitude/flight level.

Automatic altitude-keeping device.
Any equipment which is designed to control the aircraft automatically to a referenced pressure altitude.

Collision risk.
The expected number of mid-air aircraft accidents in a prescribed volume of airspace for a specific number of flight hours. (Note – one collision is considered to produce two accidents).

Cross-track frequency.
The frequency of events in which two aircraft are within a specified distance and are traveling on crossing routes at adjacent flight levels and at the planned vertical separation.

Equivalent opposite direction passing frequency.
A single value computed from a combination of same and opposite direction passing frequencies that makes the same contribution to the collision risk assessment. Allows easy comparison of different sets of same and opposite direction passing frequencies.

Flight technical error (FTE).
Difference between the altitude indicated by the altimeter display being used to control the aircraft and the assigned altitude/flight level.

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

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

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

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

Operational Error.
A vertical deviation from the correct flight level due to an ATC-Pilot loop error or an incorrect clearance

***Planned vertical separation*.**
Planned vertical separation is the planned spacing provided between aircraft in the vertical plane to avoid collision.

***Position error*.**
That portion of the static source error due to the position of the static probe/port on the aircraft (See static source error).

***Static source error*.**
The difference between the pressure sensed by the static system at the static port and the undisturbed ambient pressure in a given condition.

***Static source error correction (SSEC)*.**
A correction which may be applied to compensate for the static source error associated with an aircraft.

Technical Error.
Refers either to Altimetry System Errors or Flight Technical Errors

***Target level of safety (TLS)*.**
A generic term representing the level of risk which is considered acceptable in particular circumstances.

***Total vertical error (TVE)*.**
Vertical geometric difference between the height of the actual pressure altitude flown by an aircraft and height of its assigned pressure altitude (flight level).

***Vertical passing frequency*.**
The frequency of events in which two aircraft are in longitudinal overlap when traveling in the opposite or same direction on the same route at adjacent flight levels and at the planned vertical separation.

PART 1 – INTRODUCTION

1.1 Background

1.1.1 In the mid-1970s, world fuel shortages and increased fuel costs heightened awareness of the need for more efficient use of airspace. These forces highlighted the need for a detailed examination of the feasibility of reducing the vertical separation minimum (VSM) above flight level (FL) 290 from 600 m (2000 ft) to 300 m (1000 ft). Consequently, at its fourth meeting (in 1980), the International Civil Aviation Organization (ICAO) Review of the General Concept of Separation Panel (RGCSP) concluded that, despite the cost and time involved, the potential benefits of this measure were so great that States should be encouraged to conduct the major evaluations necessary.

1.1.2 In 1982, coordinated by the RGCSP, States initiated comprehensive programs to study the question of reducing the VSM above FL 290. Studies were carried out by eight States: Canada, Japan, France, the former Federal Republic of Germany, Kingdom of the Netherlands and the United Kingdom, the former Union of Soviet Socialist Republics and the United States of America. In December 1988 the results were presented to the RGCSP at its sixth meeting (RGCSP/6).

1.1.3 These studies employed quantitative methods of risk assessment to support operational decisions concerning the feasibility of reducing the VSM. 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).

1.1.4 Integral to the process of risk estimation for the vertical plane was the determination of the accuracy of height-keeping performance of the aircraft population operating at and above FL 290. This was achieved through the use of high precision radars to determine the actual geometric height of aircraft in straight and level flight. The radar measured aircraft height was then compared with the geometric height of the FL to which the aircraft had been assigned to determine the total vertical error (TVE) of the aircraft in question. Given this knowledge for the aircraft population, 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. Similarly, while the RGCSP assessment of TLS was derived to apply to this contribution to collision risk only, it did not encompass the contributions from other sources of vertical collision risk such as emergency descents or any form of human error.

1.1.5 The recognition of the fact that there were several sources of vertical risk error in addition to vertical navigation errors played a role in the choice of TLS values by States during their studies. Several approaches were followed in order to establish an appropriate range of values; these included taking all en route mid-air collisions and the implicit period between collisions, and adjusting the TLS until the period of time became acceptable. However, the primary approach, and the traditional manner, was to use historical data from global sources, predicted forward to about the year 2000 to provide a safety improvement and to apportion resultant risk budgets to derive the vertical collision risk element.

1.1.6 The derived values for the TLS ranged between 1×10^{-8} and 1×10^{-9} fatal accidents per flight hour. On the basis of these figures, the RGCSP employed an assessment TLS of 2.5×10^{-9} fatal accidents per aircraft flight hour to assess the technical feasibility of a 300 m (1000 ft) VSM above FL 290. That same TLS was used to develop aircraft height-keeping capability requirements for operating in a 1000 ft VSM.

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

a) airworthiness performance requirements embodied in a comprehensive minimum aircraft system performance specification (MASPS) for all aircraft utilizing the reduced separation;

b) new operational procedures; and

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

1.1.8 At the seventh meeting of the RGCSP (November 1990), the Panel completed the global guidance material for the implementation of the 1000 ft reduced vertical separation minimum (RVSM). The main purpose of the material (Doc 9574) was to provide regional planning groups (RPG) with the criteria, requirements and methodology for the development of documents, procedures and programs to enable the introduction of the RVSM within their particular region. The panel also noted that further detailed work by RPGs would be required to establish the conditions for the implementation of the RVSM in each region individually, and that any necessary amendment to the ICAO Regional Supplementary Procedures (ICAO Doc 7030) should be developed by the RPG concerned. In particular, the panel drew the attention of RPGs to the need to employ operational judgment in the determination of the tolerable level of risk attributable to those error causes not encompassed by the global TLS (i.e., assessment TLS of 2.5×10^{-9}). The panel also considered that the NAT Region would be suitable for the early implementation of the RVSM because of the essentially uni-directional flow of the NAT traffic and the better than average height-keeping accuracy of the minimum navigation performance specification (MNPS) approved aircraft population.

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

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

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

c) it would be necessary to adopt a broader definition of vertical risk that encompassed all sources of error. The definition would include equipment errors for which MASPS had been developed as well as pilot and controller operational errors. Accordingly it was agreed that the TLS be increased from 2.5×10^{-9} to 5×10^{-9} in order to be consistent with the new definition. The NAT SPG concluded (Conclusion 27/22) that:

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

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

1.1.10 The MASPS were developed by specialist groups who translated the TVE distribution requirements into detailed specifications and procedures controlling the height-keeping standards of aircraft operating in RVSM airspace. The detailed specifications and procedures were developed for use by designers, manufacturers, operators and approval authorities, and are applicable for airworthiness approval to groups of aircraft and to individual aircraft.

1.1.11 The Third Asia Pacific Regional Air Navigation meeting in 1993 was of the opinion that, after an examination of the capacity needs, fuel-saving benefits and height-keeping performance on the Pacific routes was conducted, an RVSM implementation schedule should be developed for the Asia Pacific Region. In light of this, the meeting concluded (Conclusion 6/4) that the Asia Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) undertake to evaluate RVSM benefits, including requirements of adjacent regions, and develop Asia Pacific implementation plans and schedules as appropriate. States were further directed (Conclusion 6/5) to take into account material on RVSM published by ICAO, to include the guidance material in Doc 9574 and the advisory material developed by the NAT SPG.

1.1.12 Similarly, the eighth meeting of the APANPIRG (Decision 8/10) tasked the Air Traffic Services/Aeronautical Information Services/Search and Rescue Sub-Group (ATS/AIS/SAR SG) to develop appropriate procedures, guidelines and implementation plans for the introduction of RVSM and evaluate its benefits.

1.1.13 This guidance material has been developed for the Asia Pacific Region based on the ICAO Manual on Reduced Vertical Separation Minimum (Doc 9574), the current work of the RGCSP, ~~and~~ NAT Doc 002, and the Guidance Material on the Implementation of a 300 m (1000 ft) Vertical Separation Minimum (VSM) for Application in the Airspace of the Pacific Region. Additionally this material takes into consideration the experience gained during the NAT and Pacific RVSM implementations, which ~~was~~ were implemented in three phases:

Verification Phase. The region continues to operate with 2000 ft VSM while data is collected to verify that the system would be safe with 1000 ft VSM.

Trial Phase. 1000 ft operations begin and all systems are monitored to ensure safe operation.

Operational Phase. Full RVSM. Monitoring and risk assessment continue to build confidence in the continued safe operation of RVSM.

1.2 Scope and purpose of the document

1.2.1 This document seeks to address all aspects of implementation and operation of a 1000 ft VSM within the ~~PAC~~Asia Pacific Region. Designated RVSM routes and airspace will be specified ~~initially~~ by NOTAM and ~~finally~~ published in the ICAO Regional Supplementary Procedures (ICAO Doc 7030).

1.2.2 Aircraft intending to operate using RVSM will be required to carry and use such equipment as detailed in the RVSM MASPS. These MASPS have been derived in order to achieve a minimum vertical navigation accuracy or height-keeping performance that will support the introduction of the 1000 ft RVSM.

1.2.3 ~~——~~The purpose of this guidance material is to:

a) consolidate the RGCSP guidance material on the implementation of a 300 m (1000 ft) VSM, in order to meet the particular demands of the ~~PAC~~Asia Pacific airspace;

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

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

d) form a basic reference document for use State authorities in developing procedures and documentation for aircraft and operator approval.

PART 2 – OPERATION OF THE RVSM AIRSPACE

2.1 Basic requirements

2.1.1 The overriding consideration in the introduction and continued operation of the 1000 ft RVSM in ~~PAC~~Asia Pacific airspace is that the risk of collision as a consequence of a loss of vertical separation, from any cause, is less than the agreed TLS of 5×10^{-9} fatal accidents per flight hour. This condition gives rise to the following basic requirements:

a) All aircraft intending to operate in the RVSM airspace must be equipped and maintained in accordance with the MASPS and the associated State airworthiness procedures. Appropriate guidance is provided in Part 3 as well as in the appendices.

b) All aircraft intending to operate in the RVSM airspace must have the specific approval for such operations from either the aviation authority of the State in which the aircraft is registered or the aviation authority of the operator. The approval will encompass the aircraft equipage, aircraft maintenance, airworthiness procedures, flight crew training, and operating procedures. The responsibility for gaining the necessary approval rests with the aircraft operator. State aviation authorities, however, will be expected to maintain regular checks and records of the approvals which they have granted. The relevant guidance is detailed in Part 4.

c) The flight crew should operate the aircraft in accordance with recommended operating procedures. These procedures will be approved by the appropriate State authority and should be based on the material in Part 5.

d) The ATS provider States will be responsible for developing the procedures necessary to support RVSM. Further guidance is provided in Part 6 of this document. ATS provider States should be aware that the transition to/from adjacent 2000 ft airspace should be effected, wherever possible, within radar coverage and where direct controller/pilot communications are available.

e) The fifth basic requirement is a means to monitor the system performance in order to ascertain that the foregoing measures have the desired effect (i.e., the TLS is being met). As the vertical TLS encompasses all causes of vertical risk, it is important that all known assigned altitude deviations (AAD) are reported. Sources of information include:

   i) data from height monitoring systems;

   ii) AAD from Mode C deviations reported by air traffic control (ATC);

   iii) routine position reports to ATC which identify operations at incorrect FLs;

   iv) incident reports; and

   v) specific data collections (e.g., aircraft digital flight data recorders, Mode C, etc.)

2.1.2 It is most important that ATS providers record and report to the regional monitoring agency all instances of height deviations in the ~~PAC~~Asia Pacific Region. The detailed procedures are described in Part 8 of this document.

2.2 The Global System Performance Specification and the RVSM MASPS

2.2.1 Although the NAT Region was the first to implement RVSM, it was anticipated that other regions would follow. When developing requirements for RVSM operations, RGCSP considered worldwide conditions. It is important, particularly in respect of aircraft performance, that consistent specifications be applied in all RVSM airspace. Therefore the aircraft height keeping performance requirements which were applied in the NAT Region and are to be applied in the ~~PAC~~Asia Pacific Region will be based on the global requirements developed by RGCSP. An important secondary objective during the implementation of RVSM in the ~~PAC~~Asia Pacific Region will be the demonstration that the global requirements are being met.

2.2.2 In order to determine requirements for the height keeping performance of aircraft for use in an RVSM environment, three pieces of information are required. These are the TLS, the vertical passing frequency and the lateral navigation accuracy of the aircraft population.

2.2.3 As described in the introduction, the TLS for the global implementation of RVSM derived by RGCSP is 2.5×10^{-9} fatal accidents per flight hour. This TLS value applies to the risk of collision associated with vertical navigation performance, termed “height-keeping performance.” It does not address the risk arising from either errors in ATC instructions or loss of vertical separation associated with in-flight emergencies.

2.2.4 The vertical passing frequency is a measure of the number of times that aircraft are on adjacent flight levels at the planned vertical separation. This parameter reflects both traffic densities and patterns, and its value varies considerably from region to region. The larger the value of passing frequency, the greater the collision risk per flight hour. In order to ensure that the required height keeping performance would ensure safe RVSM operations in any region, it was necessary to choose a value for the vertical passing frequency that would be unlikely to be exceeded in any airspace for some time. An equivalent opposite[1] direction passing frequency of 2.5 per flight hour was determined to be appropriate for any airspace up to the year 2005. (For comparison, the equivalent opposite direction passing frequency for the NAT Region in 1994 was approximately 0.25.)

2.2.5 Lateral navigation accuracy has an effect on the vertical collision risk, as this parameter determines the size of the probability of lateral overlap between two aircraft nominally on the same track. Therefore, the better the lateral navigation accuracy, the higher the vertical risk. To calculate the global performance requirements for technical height keeping capability, RGCSP chose a value of not less than 0.03 NM for the standard deviation of lateral navigation accuracy. This value was considered appropriate for en route navigation up to the year 2005. (For comparison, a standard deviation of lateral navigation accuracy of 1.76 NM was estimated in 1991 for NAT MNPS airspace.)

2.2.6 Using these values for the TLS, passing frequency and lateral navigation accuracy, the maximum allowable value for the vertical overlap probability can be calculated (i.e., the probability that two aircraft nominally separated by one separation standard are in fact in vertical overlap). The value for vertical overlap probability is determined by the height keeping performance of the population of aircraft. A value of 1.7×10^{-8} was derived by RGCSP.

2.2.7 Together, the passing frequency, lateral overlap probability and vertical overlap probability make up the global system performance specification. They are considered to be critical parameters that characterize a worst case airspace environment in terms of vertical collision risk. The levels of these parameters were derived to hold at least until the year 2005. The specification also defines height-keeping performance required from aircraft in order to ensure that the collision risk in such a

[1] Passing frequencies can be broken down into same direction and opposite direction. These two components can be combined to give an equivalent opposite direction passing frequency which makes the same contribution to collision risk.

worst case airspace would not exceed 2.5 x 10^{-9} fatal accidents per flight hour. The quantitative statement of the global system performance specification is:

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

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

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

2.2.8 The assessment of compliance with the global vertical overlap probability requirement is a complex mathematical process. In order to relate these requirements to aircraft height keeping performance, a global height keeping performance specification was derived. This specification must be met by the aggregate of TVE performance in the airspace. The global height keeping performance specification requires the simultaneous satisfaction of the following four conditions.

a) the proportion of TVE beyond 300 ft in magnitude is less than 2.0 x 10^{-3};

b) the proportion of TVE beyond 500 ft in magnitude is less than 3.5 x 10^{-6};

c) the proportion of TVE beyond 650 ft in magnitude is less than 1.6 x 10^{-7};

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

2.2.9 To ensure that aircraft operating in the ~~PAC~~Asia Pacific Region meet the requirements of the global height keeping performance specification, a MASPS has been developed. The MASPS consists of detailed specifications and procedures for designers, manufacturers, operators and approval authorities. The requirements of the MASPS are described in Part 3. The mechanisms proposed to show that the requirements of the global system performance specification are met are outlined in Part 7 of this document.

2.2.10 It should be emphasized that compliance with the global system performance specification will not automatically ensure that the overall system TLS of 5 x 10^{-9} fatal accidents per flight hour is met. Additional sources of error must also be monitored and the contribution of these to the overall collision risk must be assessed.

2.3 Planning for Monitoring

2.3.1 The plan for assessing height-keeping performance in the ~~PAC~~Asia Pacific Region during the verification and operational trial period, as well as after full implementation, takes into account the following factors:

a) the size of the data sample necessary to assess the overall airspace system safety based on such factors as the level of statistical confidence;

b) the priorities for specific monitoring targets to achieve a representative sample from the monitoring programs. This will include consideration of priorities for individual aircraft types, individual aircraft types used by individual operators, and individual airframes; and

c) the capability to monitor for AAD, operational errors, and large height deviations.

2.4 Verification and Trials

General

2.4.1 During the verification phase, each aircraft group of each operator not previously approved for RVSM operations must undergo verification of height keeping performance. This should be accomplished by carriage of a Global Positioning System (GPS) Monitoring Unit (GMU) since there will not be a fixed location height monitoring unit available within the region for the Pacific verification and trials.

> *Note:* Although GMU carriage does not necessarily have to be done on a ~~PAC~~Asia Pacific flight, it must be carried out in level flight between FL 290 and FL 410.

2.4.2 During operational trials and after RVSM implementation, each operator must cooperate with the regional monitoring agency in the collection of altitude keeping performance data for each aircraft type in order to be approved to operate that aircraft type in RVSM airspace.

Verification Phase

2.4.3 Before implementing RVSM and while in a 2000 ft environment, it will be necessary to verify that the level of safety of the proposed RVSM system would remain at or below the TLS. This verification phase is planned to continue for one year and to demonstrate that:

a) the TLS of 5.0×10^{-9} fatal accidents per flight hour due to the loss of vertical separation would be met in a 1000 ft environment;

b) aircraft approved for RVSM have height-keeping performance consistent with the MASPS discussed in Part 3. This will be achieved by ensuring that:

  i) the causes of height-keeping errors which were found to be inconsistent with the global height-keeping performance specification are remedied and the aircraft re-monitored;

  ii) any adverse trends or errors which might ultimately result in unacceptable performance for any individual aircraft or group of aircraft are remedied and, if necessary, re-monitored to demonstrate compliance;

  iii) additional emphasis be placed on monitoring aircraft groups that are known to exceed MASPS requirements before airworthiness procedures were applied;

  iv) aircraft registrations reported to the regional monitoring agency are properly recorded; and

  v) the height monitoring program observed a sample of aircraft and operators approved for RVSM which is representative of the full population such that those aircraft not observed are expected to have performance consistent with the MASPS.

c) operational procedures adopted for RVSM operations are effective and appropriate; and

d) the height monitoring program is effective.

2.4.4 The data collected during the verification phase is used to assess whether the risk in the system will remain at or below the TLS into the future with consideration given to traffic increases and lateral navigation improvements due to new technology.

2.4.5 The number of approved aircraft is used to assess if the trial phase of RVSM can support the implementation of RVSM at all flight levels between 290 and 410, inclusive. This assessment should include consideration for aircraft not capable of attaining approval.

Trial Phase

2.4.6 After the 2000 ft verification phase, a further one year trial period of operation with 1000 ft separation will occur. During this trial phase, all the verifications performed in the 2000 ft environment will continue. The purpose of this phase is to ensure that the predictions and simulations performed during the Verification Phase accurately reflected the true performance of the system. The operation of the system will be identical to that which will be in place for the Operational Phase, but performance and safety will be more closely monitored to ensure that nothing was overlooked during the Verification Phase. Studies performed during this trial phase will be used to confirm and then to build statistical confidence that the risk in the system is at or below the TLS and to assess whether it will remain so, taking into account increases in traffic and improvements in lateral navigation performance.

2.4.6.1 In addition, this trial phase is planned to demonstrate that:

a) aircraft not approved are effectively restricted from RVSM airspace,

b) the causes of altimetry system errors (ASE) which exceed MASPS requirements are identified and remedied, and

c) the operator of any airframe that exceeds ASE requirements is notified and restricted from RVSM airspace until the problem with airframe performance is corrected, the airframe is re-monitored and demonstrates ASE compliance.

Operational Phase

2.4.8 Once the Trial Phase is successfully completed, the Operational Phase will begin. This entails the normal operation and monitoring of the performance of RVSM in the ~~PAC~~Asia Pacific Region. The assessment of the safety of the system will be limited to an annual appraisal. Data on the height keeping performance of aircraft in the region will continue to be collected in order to build confidence that the global performance specification is being met. The effectiveness of the monitoring program will be reviewed annually.

PART 3 - AIRWORTHINESS

3.1 Introduction

3.1.1 The MASPS have been published by the Federal Aviation Administration (FAA) as interim guidance (Appendix A) and by the Joint Aviation Authorities (JAA) as a temporary guidance leaflet (Appendix E). These documents detail the airworthiness, continuing airworthiness, and operations programs necessary to approve operators and airplanes to conduct flight in airspace where RVSM is implemented.

3.1.2 The following characteristics have been used to develop aircraft engineering requirements for RVSM aircraft approval. For in-service aircraft, the airworthiness approval documents have taken the form of aircraft manufacturers' Service Bulletins, Aircraft Service Changes, and Supplemental Type Certificates. These documents are available~~l~~ for most in-service aircraft. RVSM requirements have also been incorporated into the certification of most newly manufactured aircraft.

3.1.3 Characteristics were developed in accordance with the conclusions of the RGCSP/6 Meeting (ICAO Doc 9536) to satisfy the distribution limits on TVE and to result in aircraft airworthiness having negligible effect on meeting the requirements. They are applicable statistically to individual groups of nominally identical aircraft operating in the airspace. Furthermore, they describe the performance which the groups need to be capable of achieving in service, exclusive of human factors errors and extreme environmental influences, if the airspace system TVE requirements are to be satisfied. The requirements, which were the basis for development of the MASPS, are as follows:

a) the mean ASE of the group shall not exceed ±25 m (±80 ft);

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 shall be such that the error frequency decreases with increasing error magnitude at a rate which is at least exponential.

3.1.4 The above characteristics should be used to derive type approval standards for design capability, but they address primarily the central part of the TVE distribution requirements. In order to restrict the aircraft and equipment aspects of the tail distribution, it will also be necessary to develop detailed specifications and procedure covering production release, and continued airworthiness.

3.2 Airworthiness approval

Introduction

3.2.1 Airworthiness approval must in all cases be against the requirements of the MASPS, which comprise specifications and procedures for the separate aspects of type approval, release from production, and continued airworthiness. These separate aspects of approval, and their applicability to the approval of existing aircraft, are presented below.

3.2.2 All approvals are applicable to an individual aircraft or to a group of aircraft which are nominally identical in aerodynamic design and items of equipment contributing to height-keeping accuracy, as defined in paragraph 3.3.3 below.

Definition of aircraft type groupings

3.2.3 When grouping similar aircraft together, from the viewpoint of approval or evaluation of height-keeping standards or requirements, it must be recognized that aircraft with closely similar or apparently identical type or series designations are in some cases substantially different in aerodynamic design and avionics equipment. Conversely, aircraft with different series designations can be identical in all characteristics contributing to height-keeping ability.

3.2.4 It is therefore necessary to ensure that all individual aircraft deemed to comprise a group are of identical design and build with respect to all details which could influence the accuracy of height-keeping performance. All aircraft of the same group must have been designed and assembled by one manufacturer. The airframes' pitot/static system must be installed in an identical manner and position, and, if required, the same corrective actions must be embodied to meet the RVSM requirements. All aircraft in a group must have the same altimetry, altitude-hold, and altitude-alert systems as originally installed and must be able to meet compliance with RVSM requirements. Any variation in the above from initial installation must have clearance by the airframe manufacturer or recognized design organization to show RVSM compliance has not been impaired.

3.2.5 This should not be taken to exclude approval by similarity, but where there are differences, the possible influence of all these details should be assessed before granting approval or extending approval to cover such variations.

Aircraft type approval

3.2.6 Care should be taken when assessing an approval package that flight calibration data used as a basis for evaluating residual position error are representative of the aircraft and its typical operational envelope in RVSM airspace. All error sources and variations, including uncertainties inherent in such flight calibration data, should be accounted for in the approval process. In addition, data should be developed for the operating extremes of the aircraft in the RVSM operational envelope.

3.2.7 Good design, manufacturing, certification and maintenance practices produce a level of equipment reliability that supports RVSM. In order to ensure that overall system integrity remains at a high level, it should be demonstrated analytically during the airworthiness approval process that the occurrence of undetected altimetry system failure should be better than 1×10^{-5} per flight hour. It is acceptable in this analysis to take into account the requirement for redundant altimetry systems and the ability of the flight crew to detect altimetry system failure through cross-checking procedures.

Release for flight from production

3.2.8 Specifications and procedures are incorporated into the MASPS to ensure that all individual aircraft covered by a group approval, which are manufactured or modified to meet approval standards subsequent to the granting of that approval, satisfy the requirements. These procedures would ideally include a flight test at a minimum of one point in the operational envelope on all aircraft to demonstrate production similarity. Flight test requirements may be relaxed to an appropriate level of sample testing, depending on the level of production repeatability which the manufacturer is able to validate. It may be possible to use data already available from TVE measurements to demonstrate a particular manufacturer's capability for production repeatability. In that case it must also be shown that the uncertainties associated with the data, including their applicability to the individual aircraft group under consideration, do not invalidate the conclusions.

Continued airworthiness

3.2.9 Specifications and procedures should be developed and incorporated in the maintenance requirements of the MASPS for ensuring that all individual aircraft continue during the service life to satisfy the requirements developed according to paragraphs 3.2 and 3.3 above. These procedures should include some type of periodic flight test demonstration of height-keeping accuracy. The interim guidance material at Appendix A illustrates these procedures. It may be acceptable to use independent TVE monitoring facilities to satisfy this requirement, provided that the errors and uncertainties associated with the measurements are shown to be consistent with the requirements, and provided the separate contributions to TVE of airframe, avionics and flight technical error (FTE) can be assessed. The periodic interval required will not necessarily be the same for all aircraft, and it may be possible to use data already available from TVE measurements to determine the appropriate validation interval.

Approval of existing aircraft

3.2.10 The following guidance is given regarding how the elements of the MASPS should be applied:

a) Type approval. The MASPS requirements in Appendix A are applicable. In many cases it is likely that there will already be sufficient flight test data available from the type development program to satisfy that part of the approval requirements. In other cases, it may be possible to use independent TVE data to satisfy the flight test approval requirements. In this case, a detailed assessment of the type groupings to which those data are applicable can be made, and the errors and uncertainties associated with those data are shown to be consistent with the requirements. If the original flight test data and independent TVE data are insufficient to support the approval requirements, it will then be necessary to generate new data. When assessing design capability from data obtained from aircraft which have been in service for an extended period, it is permissible to make an allowance for degradation with age attributable to ASE, within the limits imposed by item b) of paragraph 3.1.2 above. Specialists should assess whether there are also aging effects due to autopilot systems. When using performance data to assess design capability, it will be necessary to gather more extensive data, for a given level of confidence, than if design capability could be assessed directly.

b) Repeatability control and continued airworthiness.

   i) For in-service aircraft, it will be necessary to consider the requirements of paragraphs 3.3.8 and 3.3.9 together. It is unlikely that many existing aircraft can be shown to have undergone the production release controls envisaged in paragraph 3.3.8, but the objectives of those requirements may well be satisfied for aircraft which have been in service for an extended period by the continued airworthiness requirements of paragraph 3.3.9. Such aircraft should individually undergo the appropriate continued airworthiness checks developed under paragraph 3.3.9 above, as well as meeting the type approval requirements, before being granted approval.

   ii) For young in-service aircraft it should be acceptable to assume that normal production repeatability has been achieved except where there is evidence of unusually large variations. It should be a requirement to reveal such evidence. Translation of such evidence, as is available for some aircraft from independent TVE data, into additional and specific approval requirements will depend on how well the manufacturer and/or operator can identify the source of the problem and whether it is identified as originating in production or in service.

Note: The definitions of "extended period" and "young", as used above, should be interpreted relative to the appropriate continued airworthiness validation interval developed against paragraph 3.2.9.

PART 4 - STATE APPROVAL OF AIRCRAFT FOR RVSM OPERATIONS

4.1 Approval process

4.1.1 From an agreed date of applicability, aircraft which operate in designated airspace within the ~~PAC~~Asia Pacific Region and wish to receive the benefits from RVSM must be approved for such operations. The responsibility for gaining the necessary approval rests with the aircraft operator. State aviation authorities, however, are expected to maintain regular checks and records of the approvals that they have granted. Approval encompasses 1) airworthiness approval, including continuing airworthiness, 2) operational approval, and 3) provision for monitoring.

4.2 Airworthiness and continued airworthiness approval

4.2.1 State airworthiness authorities approve aircraft as meeting the height-keeping capability requirements for operations in RVSM airspace.

4.2.2 Additionally, aircraft operators must maintain altimetry and height-keeping equipment in accordance with approved procedures and servicing schedules.

4.3 Operational approval

4.3.1 Each aircraft type or group and each airframe to be used in RVSM operations must receive airworthiness approval. The authorities granting operational approval should evaluate the airworthiness documents for each aircraft type or group and each airframe. In most cases, the airworthiness documents are expected to give the authority confidence that height-keeping will be performed at required levels. In certain cases, it may be necessary for the operator to demonstrate height-keeping performance for the aircraft type.

4.3.2 The approving authority must be satisfied that operational programs are adequate. Flight crew training as well as operations manuals should be evaluated.

4.3.3 Operational approval should be granted to conduct RVSM operations for each individual aircraft type or group. Each aircraft should receive airworthiness approval prior to being approved for use by the operator.

4.3.4 The approving authorities must develop procedures to give them confidence to grant operational approval based on paragraph 3.1.2. b) above.

4.3.5 If in-service experience shows that the height-keeping performance of a particular aircraft type utilized by an operator exceeds the requirements of paragraph 3.1.2 b) and c) above, then the operator should be required to take steps to improve performance to required levels. If performance is not improved, then operational approval for the aircraft type should be withdrawn. In cases where height-keeping performance is observed to be grossly in error, approval should be withdrawn immediately.

4.4 Provision for monitoring of aircraft

4.4.1 The operator should provide a plan for participation in the verification/monitoring program of aircraft height-keeping performance. This program should normally entail a check of at least a portion of the operator's aircraft by an independent height-monitoring system. This program is considered a necessary element of RVSM implementation. Verification and monitoring programs have the primary objective of observing and evaluating aircraft height-keeping performance to gain confidence that airspace users are applying the aircraft and/or operator approval process in an effective manner and that safety will be maintained when RVSM is implemented. It is anticipated that the necessity for such a program may be diminished or possibly eliminated after confidence is gained that the RVSM program is working as planned.

4.5 State Data Base (SDB)

4.5.1 In order to adequately monitor the RVSM airspace in the vertical plane, State aviation authorities will be expected to maintain an SDB of all approvals that they have granted for operations within the RVSM airspace. The details of the compilation and formatting of the data and the system operating parameters are under development. Ideally, the SDBs will input to the regional monitoring agency on a regular basis, which will facilitate the tactical monitoring of aircraft approval status and the exclusion of non-approved users. The Asia Pacific Approvals and Registry and Monitoring Organization (APARMO), at the FAA William J. Hughes Technical Center, serves as the regional monitoring authority for the ~~Oakland, Anchorage and Tokyo flight information~~ Asia Pacific region~~s (FIRs)~~.

4.6 Monitoring and Database Information on FAA Website

4.6.1 The FAA RVSM website contains current information on monitoring and database requirements and procedures. The website address is ***www.faa.gov/ats/ato/rvsm1.htm***.

PART 5 - FLIGHT CREW OPERATING PROCEDURES

5.1 Introduction

5.1.1 Generally, flight crew operating procedures in RVSM airspace are no different than those in any other airspace; however, the implementation of RVSM may necessitate changes to some procedures, e.g., contingency procedures (Part 7). Given the safety requirements and the effect large height deviations could have on the risk levels, crews should be reminded to exercise increased vigilance to minimise the occurrence of deviations from the assigned flight level. To this end, during routine training, flight crews should be reminded of the importance of adhering to the following in-flight procedures.

5.1.1 Appendix 4 of the FAA Interim Guidance (91-RVSM) or the JAA Temporary Guidance Leaflet–6 (TGL-6), found appended to this guidance material, should be used as source documents for the development of pilot and, if applicable, dispatch training programs for normal operations. Appendix 5 of the FAA Interim Guidance should be used as the source document for pilot and, if applicable, dispatch training on contingency procedures for oceanic operations including the Pacific. (JAA TGL 6 does not currently address contingency procedures in the Pacific.)

5.1.2 Operators must also incorporate into training programs the procedures and information related to RVSM operation published in NOTAMS and State Aeronautical Information Publications.

5.2 In-flight procedures within RVSM airspace

5.2.1 Before entering RVSM airspace, the pilot should review the status of required equipment. The following equipment should be operating normally:

a) two primary altitude measurement systems;

b) one automatic altitude-keeping device; and

c) one altitude-alerting device.

5.2.2 In the event that any of the required equipment fails prior to the aircraft entering RVSM airspace, the pilot should request a new clearance so as to avoid flight in this airspace.

> *Note*: An operating transponder is not required for entry into RVSM airspace within the ~~PAC~~Asia Pacific Region. However, the operator should determine the transponder requirements for transition areas adjacent to RVSM airspace.

5.2.3 The following actions should be accomplished while in flight:

a) emphasis should be placed on promptly setting the sub-scale on all primary altimeters to 29.92 inches Hg/1013.2 hPa when passing the transition altitude and rechecking for proper altimeter setting when reaching the initial cleared flight level (CFL);

b) in level cruise it is essential that the aircraft be flown at the CFL. This requires that particular care is taken to ensure that ATC clearances are fully understood and complied with. Except in the event of an emergency, the aircraft should not intentionally depart from the CFL without a positive clearance from ATC;

c) during cleared transition between levels, the aircraft should not overshoot or undershoot the old or new FL by more than 45 m (150 ft);

d) an automatic altitude-keeping device (AKD) should be operative and engaged during level cruise, except when circumstances, such as the need to retrim 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;

e) the altitude-alerting device should be operative and engaged;

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

Note: Consideration should be given to making use of the third altimeter, if installed, as a means of keeping the system operational. Future systems may make use of altimeter comparators in lieu of regular checks.

g) the operating altitude-reporting transponder should be connected to the altimetry system being used to control the aircraft;

h) the pilot should notify ATC of contingencies (equipment failures, weather conditions) which affect his ability to maintain his CFL and co-ordinate a plan of action. If unable to notify ATC and obtain an ATC clearance prior to deviating from the CFL, the pilot should follow established contingency procedures detailed in Part 7 to leave the assigned route or track and obtain ATC clearance as soon as possible. Examples of equipment failures and weather conditions that should be notified to ATC are:

   i) failure of all automatic AKDs aboard the aircraft;

   ii) loss of redundancy of altimetry systems, or any part of these, aboard the aircraft;

   iii) loss of thrust on an engine necessitating descent;

   iv) any other equipment failure affecting the ability to maintain CFL; and

   v) greater than moderate turbulence.

i) Pilots should use the phrase "UNABLE RVSM DUE EQUIPMENT" to advise ATC that the aircraft does not meet the requirements to operate within airspace designated for RVSM.

Note: Specific contingency procedures for flight crew and controllers are contained in Part 7.

5.3 Special emphasis items: flight crew training

5.3.1 The following items should also be emphasized in flight crew training programs:

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

b) importance of crew members' cross-checking each other to ensure that ATC clearances are promptly 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 (SSEC) and position error correction (PEC) through the use of correction cards;

d) problems of visual perception in sighting other aircraft at a distance of 300 m (1000 ft) vertical separation during night conditions, when encountering northern lights, for opposite and same direction traffic, and during turns;

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

f) relationship between the altimetry, automatic altitude control and transponder systems in normal and abnormal situations; and

g) aircraft operating restrictions (if required for the specific aircraft group) related to airworthiness approval.

5.6 Operations manuals and checklists

5.6.1 The appropriate manuals and checklists should be revised to include information and/or guidance on standard operating procedures and altimeter error limitations for ground checks. Appropriate manuals and checklists should be submitted for authority review as part of the application process.

PART 6 – ATC PROCEDURES

6.1 General

6.1.1 Implementation of RVSM requires that:

a) increased vigilance be applied to:

   i) the issuance of clearances to aircraft; and

   ii) verifying that flight crews properly understand and comply with clearances;

b) measures be taken as necessary to cope with potential concentration of traffic; and

c) controllers be advised of their responsibilities in respect of the action to be taken:

   i) when aircraft known not to be suitably equipped are flight planned into the RVSM airspace;

   ii) when informed that an aircraft has lost its capability to maintain CFL appropriate to RVSM requirements;

   iii) when the pilot requests traffic information to assist in alleviating potential visual perception problems;

   iv) to safeguard separation between aircraft when advised by the pilot that the AKD ability has degraded below RVSM airspace requirements; and

   v) when displayed altitude differs from CFL by 300 ft or more.

6.2 Military operations

6.2.1 States are reminded of the recognized responsibility in regard to military traffic as specified in the *Procedures for Air Navigation Services /Rules of the Air and Air Traffic Services* (PANS-RAC, Doc 4444), Part II, Section 6. In this regard, procedures must be developed to accommodate military flight operations that do not meet the equipment requirements listed in Part 3 of this document. These procedures shall specify how non-RVSM approved military flight operations will be conducted in RVSM airspace while being segregated from air traffic provided with a 1000 ft VSM above FL 290. Methods of operation may include:

a) the provision of temporary airspace reservations;

b) the provision of block altitudes;

c) the provision of special routes applicable only to military aircraft; and

d) the provision of special routes applicable to military aircraft requiring a 2000 ft VSM above FL 290.

6.3 Verification of approval status

6.3.1 A secondary responsibility is placed upon ATS authorities to institute routine checks of the approval status of aircraft intending to operate in an RVSM airspace. This responsibility is met by:

a) scrutinizing ATS flight plans;

b) withholding ATC clearances for operations that are not in compliance with the airspace requirements.

6.3.1.1 Individual ATS providers in a position to do so, may also expand the verification to include

a) conducting cross-checks against the central data base, and

b) questioning operators not in compliance with the airspace requirements.

6.4 Tactical monitoring of RVSM airspace

6.4.1 The controller shall verify the aircraft's RVSM approval status if a pilot requests to operate in RVSM airspace and the aircraft equipment suffix does not indicate the aircraft is approved. If the pilot does not confirm that the aircraft has State approval, then, except for an emergency situation, the controller shall not issue a clearance to operate in RVSM airspace.

6.4.2 ATS providers should provide information to the ~~PARMO~~APARMO on flights that are not accommodated in RVSM airspace.

PART 7 - PILOT AND CONTROLLER CONTINGENCY PROCEDURES

7.1 Objective

7.1.1 The following material is provided to give the pilot and the air traffic controller guidance on actions to take under certain conditions of equipment failure and encounters with turbulence. It is recognized that the pilot and controller will use judgment to determine the action most appropriate to any given situation. The guidance material recognizes that for certain equipment failures, the safest course of action may be for the aircraft to continue in RVSM airspace while the pilot and controller take precautionary action to protect separation. For extreme cases of equipment failure, however, the safest course of action may be for the aircraft to leave RVSM airspace by obtaining a revised ATC clearance or, if unable to obtain prior ATC clearance, by executing the contingency maneuver specified in the Regional Supplementary Procedures (ICAO Doc 7030) to leave the assigned route or track. Track offset procedures have been developed for publication in the ICAO Doc 7030. These procedures are applicable to aircraft operating in an organized track system (OTS) only.

7.1.2 In addition to emergency conditions that require immediate descent, such as loss of thrust or pressurization, ATC shall be made aware of the less explicit conditions that may make it impossible for an aircraft to maintain its CFL while in RVSM airspace. Controllers must react to such conditions but these actions cannot be specified, as they will be dynamically affected by the real-time situation.

7.2 Pilot in command responsibility

7.2.1 The following guidance for contingency procedures should not be interpreted in any way that prejudices the final authority and responsibility of the pilot in command for the safe operation of the airplane.

7.3 Automatic AKDs fail (e.g., autopilot altitude hold)

	The Pilot should	The Controller should
Initially	maintain CFL and evaluate the aircraft's capability to maintain altitude through manual control	
Subsequently	watch for conflicting traffic both visually and by reference to ACAS, if equipped if considered necessary, alert nearby aircraft by making maximum use of exterior lights; and broadcasting position, FL, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used)	
	notify ATC of the failure using the phrase "UNABLE RVSM DUE EQUIPMENT" and the intended course of action. Possible courses of action include:	Obtain pilot's intentions and pass essential traffic information
	maintaining CFL provided that the aircraft can maintain level;	if the pilot intends to continue in RVSM airspace, assess the traffic situation to determine if the aircraft can be accommodated through provision of lateral, longitudinal or conventional vertical separation and if so, apply the appropriate minimum
	requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft cannot maintain CFL, and ATC cannot establish lateral, longitudinal or conventional vertical separation; or	if the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible
	executing the Doc 7030 contingency maneuver to offset from the assigned track and altitude if ATC clearance cannot be obtained and the aircraft cannot maintain CFL	if adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, advise the pilot of essential traffic information, notify other aircraft in the vicinity and continue to monitor the situation notify adjoining ATC facilities/sectors of the situation

7.4 Loss of redundancy in primary altimetry systems, if the remaining altimetry system is functioning normally

The Pilot should	The Controller should
If the remaining altimetry system is functioning normally, couple that system to the automatic altitude control system, notify ATC of the loss of redundancy and maintain vigilance of altitude keeping.	acknowledge the situation and continue to monitor progress

7.5 All primary altimetry systems fail or are considered unreliable

The Pilot should	The Controller should
maintain CFL by reference to the standby altimeter (if the aircraft is so equipped)	
alert nearby aircraft by making maximum use of exterior lights and broadcasting position, FL and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used)	
Consider declaring an emergency. Notify ATC of the failure and intended course of action using the phrase "UNABLE RVSM DUE EQUIPMENT". Possible courses of action include:	assess the traffic situation to determine if the aircraft can be accommodated through the provision of lateral, longitudinal, or conventional vertical separation and, if so, apply the appropriate minimum
maintaining CFL and route provided that ATC can provide lateral, longitudinal, or conventional vertical separation	if unable to provide separation, advise pilot of essential traffic information and request pilot's intentions
	if the pilot requests clearance to exit RVSM airspace, accommodate expeditiously if possible;
requesting ATC clearance to climb above or descend below RVSM airspace if ATC cannot establish adequate separation from other aircraft	if unable to issue clearance to exit airspace, notify the pilot of traffic information, advise aircraft in the vicinity and monitor the situation
executing the Doc 7030 contingency maneuver to offset from assigned track and FL if ATC clearance cannot be obtained	notify adjoining ATC facilities/sectors of the situation

7.6 The primary altimeters diverge by more than 200 ft

The Pilot should
attempt to determine the defective system through established trouble-shooting procedures and/or comparing the primary altimeter displays to the standby altimeter (as corrected by correction cards, if required)
if the defective system can be determined, couple the functioning altimetry system to the AKD and proceed as in 7.4 above
if the defective system cannot be determined, follow the guidance in paragraph 7.5 above regarding failure or unreliable altimeter indications of all primary altimeters.

7.7 Turbulence (greater than moderate) which the pilot believes will impact the aircraft's capability to maintain CFL

The Pilot should	The Controller should
Watch for conflicting traffic both visually and by reference to ACAS, if equipped	
Alert nearby aircraft by making maximum use of exterior lights and broadcasting call sign, position, FL, nature and severity of turbulence and intentions on 121.5 MHz (as a back-up, VHF inter-pilot air-to-air frequency may be used)	
Notify ATC of intended course of action as soon as possible. Possible courses of action include:	
maintaining CFL and route provided ATC can provide lateral, longitudinal or conventional vertical separation	Assess the traffic situation to determine if the aircraft can be accommodated through the provision of lateral, longitudinal, or increased vertical separation and, if so, apply the appropriate minimum
requesting a FL change, if necessary	
executing the Doc 7030 contingency maneuver to offset from the assigned track and FL if ATC clearance cannot be obtained and the aircraft cannot maintain CFL	If unable to provide separation, advise pilot of traffic information and request pilot's intentions; notify other aircraft in the vicinity and monitor the situation. Notify adjoining ATC facilities/sectors of the situation ***Note: The ATS provider, based on this information, should consider suspending RVSM operations***

7.8 Failure of the transponder

The Pilot should	The Controller should
Notify ATC prior to entering airspace where a transponder is normally required	Take such action as prescribed by the provider State.

7.9 Meteorological conditions

7.9.1 Meteorological conditions can cause turbulence that can be detrimental to accurate height-keeping. If an aircraft reports greater than moderate turbulence and is within 5 minutes of another aircraft at 1000 ft vertical spacing, ATC will endeavor to establish 2000 ft separation by climbing/descending either aircraft.

7.9.2 It should be understood that any ATC facility may request an increase in separation minima due to adverse weather conditions which could lead to the temporary suspension of RVSM in selected areas of RVSM airspace. This may be effective during active periods of the OTS or may be effective prior to the publication of the OTS.

PART 8 - SYSTEM PERFORMANCE MONITORING

8.1 General

8.1.1 The following material is intended to provide guidance on the monitoring of the operation of RVSM in the ~~PAC~~Asia Pacific Region. Monitoring will 1) ensure that the level of collision risk does not exceed the regional TLS, and 2) assess the compliance of aircraft with the global height keeping performance specification (section 2.2 refers). Information gathered by the monitoring agency will be one factor taken into account by decision-makers in judging whether overall safety goals applicable to ~~PAC~~Asia Pacific RVSM airspace are being achieved.

8.1.2 The criterion for safety in the ~~PAC~~Asia Pacific Region is that the TLS of five fatal accidents in 10^{9} flying hours (representing the risk due solely to the loss of vertical separation from any cause) is satisfied.

8.1.3 The height-keeping errors that lead to collision risk can be divided into two categories; technical errors and large height deviations. Technical errors are caused by inaccuracies in the height-keeping equipment of aircraft: ASE and FTE. Large height deviations are caused by:

a) operational errors (aircraft at other than the assigned flight level due to ATC pilot-loop errors and incorrect clearances);

b) aircraft contingency events occurring in situations where the pilot cannot initially follow normal contingency procedures and is forced to descend through flight levels before diverting from track;

c) deviations due to the effect of high level meteorological conditions, and

d) deviations due to TCAS resolution advisories.

8.1.4 Aircraft in the ~~PAC~~Asia Pacific oceanic airspace are controlled primarily through the application of procedural separation, with ATC monitoring being restricted to pilot position reports at waypoints. Therefore, large height deviations make a more significant contribution to the overall collision risk than in a radar-monitored environment. The TLS has been chosen to take account of the risk from both technical errors and large height deviations.

8.1.5 In order to ensure that the TLS is not exceeded, it is necessary initially to monitor both the occurrence of vertical errors and some CRM parameter values; other CRM parameters should be monitored on a continuing basis. Many of the parameter values used in the CRM are based on a planning horizon of approximately 10 years and require periodic monitoring.

8.1.6 CRM parameters fall into two groups from the standpoint of monitoring requirements. The first group consists of three parameters that are critical for safety assessment, in the sense that the actual risk in the airspace changes in proportion to changes in their values. The first parameter is the proportion of time spent by aircraft nominally separated by 1000 ft in vertical overlap and is a measure of the height-keeping performance of the overall aircraft population. It is termed the "vertical overlap probability" and denoted by $P_z(1000)$. The second is a measure of the number of aircraft passing events per aircraft flying hour, termed the "passing frequency". The third is a measure of the lateral path-keeping performance, termed the "lateral overlap probability" and denoted as $P_y(0)$.

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

8.1.8 It must be emphasized that the monitoring requirements, in particular the measurement of TVE, were established at a stringent level appropriate to an initial application in the first region to implement an RVSM. As a result of that initial work, the data collected, and operational experience gained, some relaxation may be possible in monitoring requirements in other regions where the RVSM is introduced as a part of the global implementation process. For example, some of the operators and aircraft types that utilize NAT RVSM airspace also operate in the ~~PAC~~Asia Pacific Region. The monitoring requirements for these operators should be greatly reduced.

8.1.9 It is important to remember that all of the measures which combine to constitute, or to verify, the height-keeping performance of an aircraft play a part in the concept of monitoring which will be applied throughout that aircraft's life and contribute to risk reduction. The measures include:

a) the requirement for aircraft to carry the equipment defined in the RVSM MASPS;

b) initial installation procedures, tests and, where necessary, flight checks of aircraft altimetry equipment;

c) compliance with State airworthiness approval procedures;

d) compliance with continued airworthiness requirements;

e) adherence to ATC procedures; and

f) adherence to pre-flight and in-flight operating procedures.

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

8.2 Collision Risk Modeling (CRM)

8.2.1 The method used to evaluate the collision risk of the system within the ~~PAC~~Asia Pacific Region is to be the same as that which was used in the original determination of RVSM feasibility, the Reich CRM. This model brings together factors of the operational system, through probabilistic and deterministic elements, to produce an estimate of the long-term average system risk for aircraft collision. For the vertical dimension, the statement of the model is given in six parts. Part 1 applies to level flight; part 2 applies to aircraft descending through flight levels; part 3 applies to aircraft adhering to the incorrect flight level; part 4 applies to intersecting routes; part 5 applies to formation flight; and part 6 applies to aircraft in vertical alignment for the entire crossing at adjacent flight levels. Each of the 6 parts of the collision risk model for the vertical dimension are given in Appendix B.

8.3 Monitoring and Assessing the Parameters of the CRM Specification

8.3.1 In order to ensure that the collision risk in ~~PAC~~Asia Pacific RVSM operations does not exceed the regional TLS, the parameters of the CRM must be monitored and assessed on a continuing basis.

8.4 Monitoring Technical Errors and Large Height Deviations to Assess $P_z(1000)$

8.4.1 The agreed TLS for the ~~PAC~~Asia Pacific Region of 5.0×10^{-9} fatal accidents per flight hour for RVSM operations requires that an assessment of total system vertical overlap probability ($P_z(1000)$) be performed. This requires that the duration of all large errors in the vertical plane be reported and assessed. In addition to technical errors detected through the height monitoring system (that is, TVE, ASE and AAD), large height deviations need to be reported.

8.4.2 An assessment of TVE is critical to an assessment of $P_z(1000)$. As a result, the accuracy with which TVE can be measured is an important concern. TVE can be measured by comparing the geometric height of an aircraft, as measured by an HMU or GMS or any other suitable system, to the geometric height of its assigned FL as measured by a suitable meteorological model. The accuracy of the measurement of TVE should be such that the mean error is 0 ft and the SD of the error does not exceed 50 ft.

8.4.3 These measured TVE data are fundamental to the monitoring process. Large amounts of such TVE data are needed to draw inference from the monitoring process with a high level of confidence. Part 2 above describes a process to support the introduction of RVSM in the ~~PAC~~Asia Pacific Region on the basis of the monitoring data.

8.4.4 Large height deviations can be divided into four main types:

a) operational errors (ATC-pilot loop errors and incorrect clearances);

b) aircraft contingency events;

c) deviations due to meteorological effects; and

d) deviations due to TCAS resolution advisories

8.4.5 Operational errors are likely to result in aircraft flying at integral multiples of the separation standard from their correct level. The long intervals between position reports, and the communication methods used, mean that operational errors make a far more significant contribution to the overall collision risk than would be the case in an airspace with air traffic control based on radar surveillance and direct communication systems. Calculations based on NAT reported occurrences of such large vertical errors indicate that these provide a dominant contribution to collision risk. The calculation of the contribution of the vertical overlap probability from these types of errors is therefore very important. Information on these types of events are obtained via ATC and pilot reports. It is vital that reports of all operational errors be sent by provider States to the regional monitoring agency

8.4.6 System risk is directly proportional to the amount of total flight time spent by aircraft at an incorrect FL. The estimates of such times will be one of the key elements to be used in determining whether or not the system is in compliance with the TLS, using appropriate mathematical and statistical methods.

8.4.7 Data sources for estimating time spent by aircraft at incorrect FLs will include reports to the regional monitoring agency by ATC authorities and airlines, as well as the results of special data gathering exercises using suitable monitoring systems.

8.4.8 Contingency events could impose a particularly large risk in oceanic airspace due to the lack of surveillance and use of indirect communications. Contingency procedures are designed to minimize these risks, but it is important that they be included in the overall analysis. If the above procedures are followed, the risk of collision with another aircraft should be minimized in most scenarios. However, it is possible that the nature of the emergency will mean that the aircraft is forced to descend through one or more levels before being able to divert from the original track. It is this descent through potentially occupied levels which will contribute the most to the collision risk. To enable the assessment of the risk, the number of levels transited before commencing the diversion from the track should be made part of the contingency report required from pilots.

8.4.9 Meteorological deviations include the effects of air turbulence and could also include rarer events such as the effects of volcanic dust clouds. Only inadvertent deviations due to external conditions are included in this category; the effects of deviations arising as a result of the deliberate avoidance of adverse weather, etc., can be determined as for contingency events.

8.4.10 When an aircraft enters turbulent air, such as that inside storm systems, its height keeping capability can deteriorate considerably. This may result in excursions from the correct pressure level which, in some cases, may be more than 1000 ft. This type of excursion will obviously add to the risk of collision and the size of the risk will be larger with smaller separation standards. The incidence of deviations caused by turbulence will require continued monitoring and analysis in order to ensure that the risk associated with such events is not excessive.

8.4.11 TCAS is an airborne collision avoidance system that is mandated by some States for all large commercial aircraft. Consequently, a large percentage of aircraft operating in the ~~PAC~~Asia Pacific Region are TCAS equipped. TCAS may give traffic advisories (TA) and resolution advisories (RA) where standard separation exists in an RVSM environment. It is necessary to evaluate the exact number and type of TAs and RAs.

8.4.12 It is important, if the extent of the height deviation is significant, that the event leading to a TCAS RA is included in the collision risk process. In ~~PAC~~Asia Pacific RVSM airspace, genuine TCAS RAs will only be issued as a result of one of the height deviation categories already described (or as a result of a lateral deviation). Nuisance RAs, on the other hand, will mostly request the pilot to return the aircraft to its original level. TCAS RAs will not normally add any "unaccounted for" risk to the system although, very occasionally, TCAS could induce a loss of separation as a result of an inappropriate RA. Each TCAS event, therefore, needs to be considered on an individual basis.

8.5 Monitoring of $P_z(1000)$

8.5.1 There are two methods that are used to estimate $P_z(1000)$. In the first method an analytical probability density function is derived directly from the proportion of TVEs of a given magnitude through statistical distribution models and then used to derive an estimate $P_z(1000)$. The second method is in two parts. For part one, analytical probability density functions are derived for each aircraft type from the proportion of ASEs of a given magnitude and then re-combined in the proportions that these aircraft types are in level flight within ~~PAC~~Asia Pacific airspace. For part two, analytical probability density functions are derived directly from AAD data and large height deviations not involving aircraft deviations at incorrect flight levels. The aggregate ASE statistical distribution model is then numerically combined with the analytical probability density function of the AAD data and large height deviations to produce a TVE statistical distribution which is then used to derive an estimate $P_z(1000)$. The first method has the advantage of directly using the monitored TVE data. The second method has the advantage of removing some of the sampling bias that may be introduced by the monitoring process and using sources of large height deviations outside of the height monitoring coverage areas.

8.6 Forecast of RVSM aircraft occupancy (passing frequencies) before RVSM implementation

8.6.1 Once RVSM has been implemented, estimated values for occupancies or passing frequencies will be obtained from a sampling program of actual operations. However, during the Verification Phase, a method is needed to forecast occupancies (or passing frequencies) in a 1000 ft VSM environment, to allow an assessment of the expected collision risk under RVSM.

8.6.2 For the NAT, RVSM analyses were conducted using a computerized NAT Traffic Allocation Model (NATTAM). A computer simulation of this type, developed by Canada, is needed in the ~~PAC~~Asia Pacific for predicting the future occupancy for use in collision risk assessment prior to implementation of RVSM in the ~~PAC~~Asia Pacific Region. To provide background and to assess the scope and capabilities of the simulation model needed for the ~~PAC~~Asia Pacific a brief description of the NATTAM is presented in Appendix C. The capabilities of the ~~PAC~~Asia Pacific simulation model should include:

a) allocation of routes, flight levels and times of flights;

b) traffic volumes and patterns;

c) structure of the airspace and track system;

d) concentration of traffic towards tracks and flight levels that aircraft operators prefer; and

e) estimation of vertical occupancies and passing frequencies.

8.6.3 Another source of input for the simulation model that could be used to refine the reallocation of flights, concentration towards core tracks and conflict resolution could be obtained by analysing the changes that occurred in the NAT before and after RVSM implementation.

8.6.7 In addition to the capabilities in the NAT simulation, the ~~PAC~~Asia Pacific simulation will need to forecast cross-track frequencies under RVSM.

8.7 Monitoring aircraft passing frequencies after RVSM implementation

8.7.1 Aircraft same, opposite and cross-track passing frequencies in the ~~PAC~~Asia Pacific Region will be assessed on a monthly basis by the regional monitoring agency using traffic data supplied by the ATC authorities. The additional high level of crossing traffic in the ~~PAC~~Asia Pacific necessitates the assessment of cross-track frequency at route intersections. It is anticipated that the level of passing frequencies will remain considerably lower than that used to derive the aircraft height-keeping performance in the global system performance specification.

8.8 Monitoring lateral overlap probability

8.8.1 The lateral overlap probability ($P_y(0)$) is the probability that two aircraft nominally on the same track are within a distance λ_y (the average aircraft wingspan) from each other laterally. The value of this parameter depends upon the accuracy of the lateral navigation of aircraft in the region and aircraft wingspan. The more accurate the navigation or the larger the wingspan, the larger the lateral overlap probability. For calculations of vertical collision risk, the errors of aircraft *entering* the ocean are used in the determination of $P_y(0)$. The standard deviation for these errors is expected to be smaller than that seen for errors of aircraft *leaving* the ~~PAC~~Asia Pacific Region, but its use ensures that the average vertical collision risk is not under-estimated. The form of the distribution used to model navigation performance in the core region also affects the value of $P_y(0)$.

8.8.2 Because, all other factors remaining constant, better lateral path-keeping accuracy increases the risk of collision due to the loss of a 1000 ft vertical separation, the regional monitoring agency will examine cross-track errors in the airspace periodically using data supplied by ATS authorities. The global height-keeping performance specification for TVE was developed under the assumption of lateral navigation accuracy with an SD of 0.3 NM. Authorities should recognize that the CRM is directly affected by changes in aircraft lateral path-keeping accuracy and should conduct periodic reviews to assess the potential effects resulting from any mandatory changes or otherwise in aircraft navigational equipage.

8.9 Monitoring other CRM parameters

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

8.9.2 The parameters relating to the physical characteristics of aircraft can all be estimated from direct observations of the system. The aircraft dimensions ($\lambda_x, \lambda_y, \lambda_z$) are obtained using the wingspan, length and height of different types of aircraft. The mean values for the ~~PAC~~Asia Pacific aircraft population are then calculated using weightings based on the frequency of crossings made by each of the types.

8.9.3 The average absolute aircraft air speed ($\overline{|V|}$) is derived using the cleared speeds of aircraft operating in the region. The accuracy of this estimate is determined by the size of the sample used. To estimate the average absolute relative along track speed ($\overline{|\Delta V|}$), traffic data for pairs of aircraft on adjacent levels are used. As with average air speed, the accuracy of this estimate is dependent upon the size of the sample.

8.9.4 The average absolute relative cross-track speed ($\overline{|\dot{y}|}$) is assessed using radar data on aircraft leaving the ~~PAC~~Asia Pacific system. This parameter is expected to be fairly stable with time, changing only gradually as new navigation systems with significantly better performance are introduced.

8.9.5 The average absolute relative vertical speed ($\overline{|\dot{z}|}$) should in theory be determined for pairs of aircraft that have lost all vertical separation. In practice, a total loss of vertical separation is unlikely to be observed. The value is therefore estimated indirectly from precision radar measurements of relative velocities for pairs of aircraft with different deviations and extrapolating to that of the separation standard in force.

8.9.7 The additional parameters λ_{xz} (same) and λ_{xz} (opp) for the length of the path in the descending aircraft collision risk model need to be determined, at present, by simulation for ~~PAC~~Asia Pacific aircraft.

8.10 Monitoring and Assessing Compliance with System Performance

8.10.1 After the parameters of the CRM have been monitored, the system can be assessed for compliance with the restrictions imposed by either the global or regional performance requirements. It is important to remember the distinction between global and regional system performance requirements. Global system performance requirements apply only to aircraft height-keeping and are designed to apply worldwide. As such, the restrictions on aircraft height-keeping and lateral performance are designed to be more stringent than may be required for regional compliance while the global restrictions on occupancy values are expected to be more lenient than the regional values (allowing for the large range of regional occupancies expected worldwide).

8.10.2 Regional system performance requirements apply to vertical deviations due to all causes. However, oceanic regional height-keeping requirements are expected to be more lenient than global requirements, since, 1) occupancies may be much lower than the values used to derive the global requirements (as is expected within oceanic airspace) and 2) lateral performance is not at the design levels used for global requirements,.

8.11 Regional System Performance

8.11.1 The determination of compliance with the regional TLS is made from two viewpoints. One perspective is gained by directly estimating the system risk by substituting each of the parameter estimates into the collision risk equations shown in section Appendix B. Following this viewpoint will result in a single estimated value for the collision risk and provides a measure which can be compared against the TLS. However, it is subject to the uncertainty imposed by each of the parameter estimates.

8.11.2 Another perspective is gained by assessing whether the TLS is being complied with to a high degree of statistical confidence. It can be applied as a forecast that the TLS will be met under RVSM or that the TLS is being met once RVSM is in place. This viewpoint does not require an estimate of the CRM parameter $P_z(1000)$. However, it relies on the confirming that the MASPS, which are designed to result in a negligible risk due to ASE for RVSM approved aircraft, are working and that the risk due to contingency events is negligible.[2] At the heart of this process is a sequential sampling risk assessment method. It compares the actual large height deviations, including operational errors and flight technical errors, to aid in deciding, with a high level of confidence, if the system is meeting the TLS, if the system is not meeting the TLS, or if more data is required.

8.11.3 Evidence from the sequential sampling risk assessment method for both the near term trial implementation and the year 2005 will be used to show whether there is a high degree of confidence that the TLS of 5×10^{-9} fatal accidents per flight hour will be complied with under RVSM or whether further monitoring of height-keeping errors (excluding ASE and contingency events) is required.

8.12 Global System Performance

8.12.1 In addition to the requirement that total system performance meet the overall TLS, the monitoring process will be used to ensure that the fleet of aircraft flying in RVSM airspace meets the global system performance specification from which the RVSM MASPS were derived (paragraph 2.2 above also refers).

8.12.2 Because the global system position performance specification, and in particular the $P_z(1000)$ of 1.7×10^{-8}, was used to derive aircraft height-keeping performance specifications which are

[2] RGCSP work suggests that risk is negligible when it is about 2 orders of magnitude less than the TLS.

expressed as requirements on TVE, only errors resulting from incorrectly operating equipment are included in this aspect of the monitoring program.

8.12.3 There are two methods that are used to assess the compliance of TVE with the global height-keeping requirements. One method directly estimates the proportion of TVEs of a given magnitude through statistical distribution models and compares the results to the TVE global requirements and one method assesses compliance with the MASPS.

8.13 Monitoring and Assessing Compliance with the MASPS

8.13.1 Given a measured TVE and a simultaneous difference between automatically reported Mode C altitude and assigned FL or AAD, it will be possible to develop an estimate of an aircraft's ASE as the difference between its TVE and AAD. It will be important to derive ASE values for airframes and for aircraft types in order to evaluate the component values of TVE, i.e., ASE and AAD.

8.13.2 The MASPS were designed so that the resulting TVE, as measured from the component values of ASE and AAD, would result in a negligible $P_z(1000)$. Assessing compliance with the global height-keeping performance specification will be made by verifying the basic assumptions used in the MASPS derivation and monitoring the performance of the component values of ASE and AAD against the MASPS requirements (paragraph 3.1.2 refers). A description of the assessment of ASE and AAD for compliance with the MASPS is given in Appendix D.

8.14 Assessment of the safety of ~~PAC~~Asia Pacific RVSM operations

8.14.1 The airspace parameters derived from the monitoring procedures outlined above allow the collision risk in the system to be assessed against the regional TLS. The height-keeping performance of aircraft can also be assessed and compared to the requirements of the global height-keeping performance specification outlined in paragraph 2.2.2 above.

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

8.14.3 During the verification period and after implementation, tabulation of details will be used to provide detailed information on the forecast of air-miss data, near mid-air collision reports or any other similar source of information of the system in terms of collision risk and aircraft height-keeping performance.

8.15 Responsibilities of the regional monitoring agency

8.15.1 Monitoring will be carried out by the regional monitoring agency and will include the monitoring of height-keeping accuracy and vertical errors. The additional duties are as follows:

a) transferring and collating aircraft height-keeping performance data from other monitoring agencies;

b) receiving reports from height monitoring systems of those height deviations which are in magnitude equal to, or greater than, the following criteria:

   i) TVE : 300 ft;

ii) ASE : 245 ft; or

iii) AAD : 300 ft;

c) receiving reports from provider States of details of operational errors and large height deviations identified in the region;

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

i) determine the likely cause of the height deviation; and

ii) verify the approval status of the relevant operator;

e) recommend, wherever possible, remedial action;

f) analyze data to detect height deviation trends and to take action as in d) above;

g) undertake data collections as required to:

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

  ii) establish or add to a data base on the height-keeping performance of:

  a) the aircraft population;

  b) aircraft types or categories; and

  c) individual airframes;

  iii) provide additional data relevant to height-keeping performance needed to conduct studies which are deemed appropriate. Such studies might include analysis of FTE in the airspace based on the analysis of flight data recording;

h) collect data on all flights entering the region from all provider States. These data should include the aircraft registration numbers to facilitate a check or approval status against a data base of approved users;

i) monitor the level of risk of collision as a consequence of operational and technical errors and emergency procedures as follows:

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

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

  iii) calculate frequency of occurrence;

  iv) assess level of risk in RVSM environment;

  v) compare level of risk due to operational errors with the level experienced in the 600 m (2000 ft) environment; and

  vi) initiate remedial action;

j) maintain a central data base of approved users and initiate checks on the "approval status" of aircraft operating in the relevant RVSM environment; and

k) circulate monthly reports on all height-keeping deviations together with such graphs and tables necessary to illustrate the estimated relation of the system risk to the TLS.

8.15.2 The United States has agreed to provide the Pacific Approvals and Registry and Monitoring Organization (~~PARMO~~APARMO), at the FAA William J. Hughes Technical Center, as the regional monitoring agency in the ~~PAC~~Asia Pacific Region~~, initially for the Oakland, Anchorage and Tokyo FIRs~~. The ~~PARMO~~APARMO is responsible for the collection, collation and dissemination of data relevant to navigation performance. Additionally, it acts as a focal point for reports of height deviations of 300 feet or more. Although there is a formalized and universally agreed procedure for dealing with gross navigation errors (GNE), no such official procedure yet exists for dealing with height deviations. Accordingly, the regional monitoring agency, during and subsequent to the RVSM verification phase will, in addition to its existing tasks, be responsible for the following:

a) initiation of checks of the approval status of aircraft operating in RVSM through tactical monitoring of the airspace;

b) maintenance of a data base of aircraft approved to operate in RVSM airspace including details of GMS monitored performance;

c) maintenance of a data base of "rogue" aircraft collated from all monitoring sources;

d) maintenance of such other data bases as necessary to monitor the TLS in respect of observed height-keeping performance criteria;

e) taking appropriate measures to ensure the minimum aircraft monitoring targets are met;

f) follow-up action and initiation of investigation of height deviations in excess of a pre-determined magnitude and develop recommendations for remedial action; and

g) production of routine reports and dissemination of monitoring data as required.

8.16 Objectives of the Height Monitoring System

8.16.1 In order to recommend a monitoring system, it was necessary first to define overall monitoring targets. Following a review of information and data collected in the vertical studies programs, it was assumed that, for planning purposes, ASE for individual airframes would be stable for a period of two years. Important objectives of the verification period were therefore to characterize the ASE performance of the airframes which will be used in the ~~PAC~~Asia Pacific Region in RVSM operations and to confirm the stability of ASE. Ongoing monitoring of aircraft in the NAT RVSM airspace is continuing to evaluate the stability of ASE.

8.16.2 On the basis of the above assumption, it was possible to establish the objectives of the monitoring program and to consider how these objectives could be met. First, the ultimate objective would be to carry out a complete census of airframes. The monitoring system should therefore be designed to be capable, in principle, of performing such a census over a period of one year. Because a complete census is an impractical target for the verification phase, the minimum targets, listed below, were agreed to in the NAT Region. They should also permit the collection of sufficient information on the height keeping performance of aircraft operating in the ~~PAC~~Asia Pacific Region:

a) sufficient airframes are measured to ensure that a minimum of 90% of flights in the ~~PAC~~Asia Pacific Region during a year would be made by aircraft which had been monitored at least once;

b) not less than 60% of all RVSM MASPS-approved airframes are monitored at least once through the monitoring process in place for ~~PAC~~Asia Pacific RVSM during the verification phase;

c) at minimum, a census of aircraft types with RVSM MASPS approvals are monitored;

d) at minimum, a census of the RVSM MASPS-approved aircraft types for every commercial operator are monitored; and

e) as many of the RVSM MASPS approved international general aviation (IGA) aircraft as possible are measured, and not less than 80% of the full population of RVSM MASPS-approved IGA aircraft. Extraordinary efforts should be made to complete a census of RVSM MASPS-approved IGA aircraft.

8.16.3 An examination of the operators and aircraft types in the ~~PAC~~Asia Pacific airspace may reveal that many aircraft were monitored while operating in NAT RVSM and that it is now feasible to attain the objective of a census of aircraft planning to operate in ~~PAC~~Asia Pacific RVSM. In that case, the monitoring goals should be adjusted to increase the likelihood of attaining a census during the ~~PAC~~Asia Pacific verification period.

8.16.4 The NAT Region designed monitoring targets as minimum objectives to ensure that a good representative sample of RVSM MASPS-approved aircraft was obtained. The data obtained from a monitoring program that met these targets would be sufficient to provide:

a) further evidence of the stability of ASE;

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

c) assurance that aircraft height-keeping performance as measured in the NAT is transferable to the ~~PAC~~Asia Pacific airspace; and

d) confidence that the TLS would be met.

8.16.5 The targets had been agreed to on the assumption that aircraft height-keeping performance would meet the global requirements. The collision risk due to this aspect of the system should then contribute only a very small part to the regional TLS. If the observed performance is significantly worse than the global height-keeping requirements, the minimum sampling requirements will be increased to ensure that the regional TLS would not be threatened.

8.17 Background Description of the NAT Height Monitoring System

8.17.1 The height monitoring system for the implementation of RVSM in the NAT Region consisted of a hybrid height monitoring system comprising HMUs and a GMS. The GMS consisted of portable GMUs, GPS reference stations, access to Mode C and MET information, post-flight processing facilities and adequate logistic support.

8.17.2 For the application of RVSM in the initial airspace it would have been very difficult to achieve the monitoring objectives with only one of the proposed monitoring systems - the HMU or the GMS. The HMUs allowed a large sample of airframes to be collected over a short time. Repeat samples of individual aircraft were collected in NAT RVSM airspace over long periods of time to help verify the assumption of ASE stability and to characterize the typical ASE range for a variety of aircraft types. Aircraft not monitored by the HMU system were candidates for monitoring by the GMS. The GMS allowed for repeat measurements of suspect airframes and monitoring to be targeted on sub-populations which were shown to be poor performers. Similarly the GMS was used to obtain samples of aircraft operators and/or types whose normal operations did not over-fly the geographical site of an HMU.

8.17.3 In addition, the constraint of the HMU's fixed location was offset by the GMS aircraft-specific capability. A complete census, by operator, type or airframe, was therefore more easily achieved by a combined system. The relatively expensive unit cost of the HMU was also counterbalanced by the reduced cost of a complementary GMS.

8.17.4 The relatively low volume of data gathered on a daily basis by the GMS was offset by the high daily data acquisition rate of the HMU. Whereas the performance of a GMS target aircraft may not have been typical “on the day”, HMU target aircraft, passively monitored, were more likely to be representative of their normal performance. The anticipated administrative and/or logistics problems of operating a stand-alone GMS was substantially relieved by the complementary contribution that the HMU system provided.

8.17.5 Therefore, the disadvantages of the HMU system were mitigated by the characteristics of the GMS and the disadvantages of the GMS were offset by the characteristics of the HMU system. In addition, there were further independent advantages associated with each system. A combination of HMUs and a GMS provided the most suitable means of achieving the verification and monitoring objectives in NAT RVSM. However, it was understood that, because of the complementary systems, both elements (HMU/GMS) were equally critical to the composition of the hybrid system.

8.18 Description of the ~~PAC~~Asia Pacific Height Monitoring System

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

a) repeat measurement of airframes to assure the stability of ASE;

b) continued monitoring of aircraft to assure that compliant height-keeping performance is maintained. In the NAT Region data, large ASEs were found on three airworthiness-approved aircraft types. Although the problem was remedied for each airframe the cause of the failures remain unknown; and

c) continued assurance that the risk in the system is maintained at a level below the TLS.

INTERIM GUIDANCE MATERIAL ON THE APPROVAL OF OPERATORS/AIRCRAFT FOR RVSM OPERATIONS

Subject: APPROVAL OF AIRCRAFT AND OPERATORS FOR FLIGHT IN AIRSPACE ABOVE FLIGHT LEVEL (FL) 290 WHERE A 1,000 FOOT VERTICAL SEPARATION MINIMUM IS APPLIED	**Date:** 6/30/99 **Initiated by:** AIR-100 AFS-400	**No.:** 91-RVSM **Change:** 1

*1. PURPOSE. This document is intended to provide interim guidance. It establishes an acceptable means, but not the only means, that can be used in the approval of aircraft and operators to conduct flight in airspace or on routes where Reduced Vertical Separation Minimum (RVSM) is applied. It contains guidance on airworthiness, continuing airworthiness, and operations programs for RVSM operations. (Appendix 7 contains a table of contents which lists where these issues are addressed in the document.) (RVSM airspace is any airspace or route between FL 290 and FL 410 inclusive where aircraft are separated vertically by 1,000 ft (300 m)).

* a. Paragraphs containing new or amended material are preceded by an asterisk.

2. RELATED FAR SECTIONS. FAR Section 91.705, FAR Section 91.411, FAR Part 145, FAR Part 121, FAR Part 135, FAR Part 43.

3. RELATED READING MATERIAL.

* a. International Civil Aviation Organization (ICAO) Doc. 9574, *Manual on the Implementation of a 300 m (1,000 ft) Vertical Separation Minimum Between FL 290 - FL 410 Inclusive*. Copies may be obtained from ICAO, Document Sales Unit, 999 University Street, Montreal, Quebec H3C 5H7, Canada; Tel.: (514) 954-8022; Fax: (514) 954-6769; E-mail: sales_unit@icao.org

b. ICAO Doc. 9536, Review of the General Concept of Separation Panel (RGCSP), Sixth Meeting, Montreal, 28 November - 15 December 1988. Copies may be obtained from address above.

c. ICAO Doc. 9572, RGCSP, Seventh Meeting, Montreal, 30 October - 20 November 1990. Copies may be obtained from address above.

4. BACKGROUND.

a. In mid-1981, the FAA established a Vertical Studies program with the objective of collecting data on aircraft height-keeping performance, developing program requirements for the reduction of vertical separation, and providing technical and operational representation on the working groups studying the subject. In early 1982, the FAA hosted a Public meeting on vertical separation. This meeting recommended that the Radio Technical Commission for Aeronautics (RTCA) should be the forum for the development of the minimum system performance standards (MSPS) for RVSM. RTCA Special Committee (SC) 150 was formed in March 1982 for this purpose.

b. In the international arena, the FAA committed resources to the ICAO RGCSP which was tasked in 1974 to add the study of vertical separation to its work program.

c. The data and analysis developed in the FAA Vertical Studies Program was reviewed by the national and international working groups studying RVSM. The major results and conclusions of this program are contained in the "Summary Report of United States Studies on 1,000 foot Vertical Separation Above Flight Level 290" which was completed in July 1988. (This report was incorporated in its entirety into Volume II of the RGCSP/6 report. Volume II is a compilation of reports from EUROCONTROL and four individual states on vertical studies).

d. RTCA 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 programs in the U.S. from 1982 to 1987. SC 150 completed its "Initial Report on Minimum System Performance Standards for Vertical Separation Above Flight Level 290 in November 1984. This report contains information on the methodology for evaluating safety, factors influencing vertical separation, and strawman system performance standards. RTCA also developed a draft "Minimum System Performance Standard for 1,000-Foot Vertical Separation Above Flight Level 290." The draft MSPS continued to develop over a period of years. Draft 7 of the material was developed in August 1990.

e. In 1987, the FAA concentrated its resources for the development of RVSM programs in the ICAO RGCSP. The U.S. delegation to RGCSP used the material developed by SC 150 in developing U.S. positions and proposals on RVSM criteria and programs.

f. The ICAO RGCSP published two major reports which have provided the basis for the development of RVSM implementation documents. The Report of RGCSP/6 (Montreal, 28 November-15 December 1988) was published in two volumes. Volume 1 summarized the major conclusions reached by the panel and by individual states. Volume 2 presented the complete RVSM study reports of EUROCONTROL, the U.S., Japan, Canada, and the USSR. The major conclusions of this report are that:

(1) RVSM is "technically feasible without imposing unreasonably demanding technical requirements on the equipment"

(2) RVSM would provide "significant benefits in terms of economy and en route airspace capacity."

g. The second major report published by RGCSP was the Report of RGCSP/7 (Montreal, 30 October - 20 November 1990). This report contains the draft "Manual on Implementation of a 300 M (1,000 ft) Vertical Separation Minimum (VSM) Between FL 290 and 410 Inclusive." This material was approved by the ICAO Air Navigation Commission in February 1991 and published as ICAO Document 9574. This manual provides guidance for RVSM implementation planning, airworthiness requirements, flight crew procedures, ATC considerations, and system performance monitoring.

h. Appendix 6 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 and programs contained in the Interim Guidance.

5. DEFINITIONS. The following definitions are intended to clarify certain specialized terms used in this advisory material:

a. Aircraft Group. A group of aircraft that are of nominally identical design and build with respect to all details that could influence the accuracy of height keeping performance (see paragraph 9b(2)).

b. Altimetry System Error (ASE). The difference between the pressure altitude displayed to the flightcrew when referenced to ISA standard ground pressure setting (29.92 in. Hg/1013.25 hPa) and free stream pressure altitude.

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

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

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

f. Basic RVSM Envelope. The range of Mach numbers and gross weights within the altitude ranges FL290 to FL410 (or max available altitude) where an aircraft can reasonably be expected to operate most frequently. (See paragraph 9b(40(ii)).

g. 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. (See paragraph 9b(4)(i)).

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

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

j. Non-Group Aircraft. An aircraft for which the operator applies for approval on the characteristics of the unique airframe rather than on a group basis. (see paragraph 9b(3)).

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

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

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

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

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

6. THE APPROVAL PROCESS.

a. General. Airspace where RVSM is applied should be considered special qualification airspace. Both the individual operator and the specific aircraft type or types which the operator intends to use should be approved by the appropriate FAA offices before the operator conducts flight in RVSM airspace. This document provides guidance for the approval of aircraft types and operators for flight in airspace where RVSM is applied.

b. Approval of Aircraft. Each aircraft type that an operator intends to use in RVSM airspace should have received FAA approval in accordance with paragraph 9 prior to the operational approval being granted. Paragraph 9 provides guidance for the approval of aircraft which have already entered service and for new build aircraft.

(1) In-service Aircraft: FAR Parts 121, 125, and 135 Operations. Aircraft manufacturers should coordinate with the appropriate Aircraft Certification Office (ACO) to determine the process and procedures for RVSM airworthiness approval. An individual operator seeking approval for its aircraft should contact the manufacturer of the specific aircraft type and their assigned Certificate Management Office (CMO) or the Flight Standards District Office (FSDO) which holds their operating certificate to determine/coordinate the process for RVSM approval. Final approval will require coordination between the operator, the CMO or FSDO, the ACO, and the aircraft manufacturer or design organization.

(2) In-service Aircraft: FAR Part 91 Operations. An aircraft manufacturer should contact their assigned ACO to determine the process and procedures for RVSM airworthiness approval. An individual operator seeking approval for its aircraft should contact the manufacturer of the specific aircraft type and their local FSDO to determine/coordinate the process for RVSM approval.

(3) New Build Aircraft. A manufacturer which desires to have a specific aircraft type approved for the RVSM operations should contact the appropriate ACO within its assigned geographical area. Manufacturers will be able to receive airworthiness approval only.

(4) Other Aircraft. For RVSM operations conducted within the United States under FAR Part 129, aircraft should be approved by the state of the operator or registry. Experimental aircraft should be approved through special flight authorizations.

c. Operator Approval. Paragraph 10 contains guidance on the continuous airworthiness (maintenance) programs for RVSM operations. Paragraph 11 contains guidance on the operational procedures and programs which an operator should adopt for RVSM operation. Each individual operator should plan on presenting these programs to the FAA at least 60 days prior to proposed operation. Paragraph 11 discusses the timing, process, and maintenance and operations material which the operator should submit for FAA review and evaluation. The appropriate FAA offices which should be contacted to start the process are as follows:

(1) FAR Parts 121, 125, and 135 Operators. The operator should notify the CMO or FSDO which holds its operating certificate of its intent to obtain approval for RVSM operations. The operator can expect the CMO or FSDO to consult the Air Transportation Operations Inspector's Handbook, FAA Order 8400.10, and Airworthiness

the Inspector's Handbook, FAA Order 8300.10, for guidance on RVSM approval and for sources of technical assistance.

(2) FAR Part 91 Operators. FAR Part 91 operators should contact their local FSDO to start the process to receive a letter of authorization (LOA) which will grant authorization for RVSM operations. The operator can expect the FSDO to consult FAA General Aviation Operations Inspector's Handbook, FAA Order 8700.1, and the Airworthiness Inspector's Handbook, FAA Order 8300.10, as necessary for guidance on RVSM approval and for sources of technical assistance.

7. RVSM PERFORMANCE.

a. General. The statistical performance statements of ICAO Doc. 9574 for a population of aircraft (see Appendix 6) have been translated into airworthiness standards by assessment of the characteristics of ASE and altitude control. The following standards differ in some respects from that document, but they are consistent with the requirements of RVSM.

b. RVSM Flight Envelopes. For the purposes of RVSM approval, the aircraft flight envelope may be considered in two parts: the Basic RVSM Envelope and the Full RVSM Envelope. (The parameters for these envelopes are detailed in paragraph 9b(4)). The Basic RVSM Envelope is the part of the flight envelope where aircraft operate the majority of time. The Full RVSM Envelope includes parts of the flight envelope where the aircraft operates less frequently and where a larger ASE tolerance is allowed (See paragraphs 7c(3) and 7c(4).

c. Altimetry System Error.

(1) In order to evaluate a system against the ASE performance statements established by RGCSP (see Appendix 6, paragraph 3), it is necessary to quantify the mean and three standard deviation values for ASE, expressed as ASE_{mean} and ASE_{3SD}. In order to do this, it is necessary to take into account the different ways in which variations in ASE can arise. The factors which affect ASE are as follows:

(i) Unit to unit variability of avionics.

(ii) Effect of environmental operating conditions on avionics.

(iii) Airframe to airframe variability of static source error.

(iv) Effect of flight operating condition on static source error.

(2) Assessment of ASE, whether based on measured or predicted data, must, therefore, cover paragraphs 7c(1)(i), 7c(1)(ii), 7c(1)(iii) and 7c(1)(iv). The effect of item (iv) as a variable can be eliminated by evaluating ASE at the most adverse flight condition in an RVSM flight envelope.

(3) The requirements in the Basic RVSM Envelope are as follows:

(i) At the point in the Basic RVSM Envelope where mean ASE reaches its largest absolute value, the absolute value should not exceed 80 ft (25m).

(ii) At the point in the Basic RVSM Envelope where mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 200 ft (60m).

(4) The requirements in the Full RVSM Envelope are as follows:

(i) At the point in the Full RVSM Envelope where mean ASE reaches its largest absolute value, the absolute value should not exceed 120 ft (37)m.

(ii) At the point in the Full RVSM Envelope where mean ASE plus three standard deviations of ASE reaches its largest absolute value, the absolute value should not exceed 245 ft (75m).

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

(5) Aircraft types for which application for type certification or major change in type design is made after January 1, 1997 should meet the criteria established for the Basic Envelope in the Full RVSM Envelope. (See paragraph 7c(3)). The FAA will consider factors that provide an equivalent level of safety in the application of this certia as stated in FAR section 21.21b(1).

(6) The requirement of ICAO Doc. 9574 that each individual aircraft in the group should be built to have ASE contained within ±200 ft (±60 m) is discussed in paragraph 9b(5)(iv)(F).

(7) The standards of paragraphs 7c(3), 7c(4) and 7c(5) cannot be applied to nongroup aircraft approval because there can be no group data with which to develop airframe to airframe variability. Therefore, a single ASE value has been established that controls the simple sum of the altimetry system errors. In order to control the overall population distribution, this limit has been set at a value less than that for group approval.

(8) Accordingly the standard for aircraft submitted for approval as nongroup aircraft, as defined in paragraph 9b(3) is as follows:

(i) For all conditions in the Basic RVSM Envelope:

$$\left| \text{Residual static source error + worst case avionics} \right| \leq 160 \text{ ft (50 m)}$$

(ii) For all conditions in the Full RVSM Envelope:

$$\left| \text{Residual static source error + worst case avionics} \right| \leq 200 \text{ ft (60 m)}$$

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

d. Altitude Keeping. An automatic altitude control system should be required and it should be capable of controlling altitude within ±65 ft (±20 m) about the acquired altitude when operated in straight and level flight under nonturbulent, nongust conditions.

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

8. AIRCRAFT SYSTEMS.

a. Equipment for RVSM Operations. The minimum equipment fit should be as follows:

(1) Two independent altitude measurement systems. Each system should be composed of the following elements:

(i) Crosscoupled static source/system, provided with ice protection if located in areas subject to ice accretion;

(ii) Equipment for measuring static pressure sensed by the static source, converting it to pressure altitude and displaying the pressure altitude to the flightcrew;

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

(iv) Static source error correction (SSEC), if needed to meet the performance requirements of paragraphs 7c(3) and 7c(4), or 7c(8), as appropriate; and

(v) The equipment fit should provide reference signals for automatic control and alerting at selected altitude. These signals should preferably be derived from an altitude measurement system meeting the full requirements of this document, but must in all cases enable the requirements of paragraphs 8b(6) and 8c to be met.

(2) One SSR altitude reporting transponder. If only one is fitted, it should have the capability for switching to operate from either altitude measurement system.

(3) An altitude alert system.

(4) An automatic altitude control system.

b. Altimetry.

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

(i) Airframe plus static sources.

(ii) Avionics and/or instruments.

(2) Altimetry System Outputs. The following altimetry system outputs are significant for RVSM operations:

(i) Pressure altitude (Baro Corrected) display.

(ii) Pressure altitude reporting data.

(iii) Pressure altitude or pressure altitude deviation for an automatic altitude control device.

(3) Altimetry System Accuracy. The total system accuracy should satisfy the requirements of paragraphs 7c(3) and 7c(4), or 7c(8), as appropriate.

(4) SSEC. If the design and characteristics of the aircraft and altimetry system are such that the standards of paragraphs 7c(3) and 7c(4), or 7c(8), are not satisfied by the location and geometry of the static sources alone, then suitable SSEC should be applied automatically within the avionic part of the altimetry system. The design aim for static source error correction, whether aerodynamic/geometric or avionic, should be to produce a minimum residual static source error, but in all cases it should lead to satisfaction of the standards of paragraphs 7c(3) and 7c(4), or 7c(8), as appropriate.

(5) Altitude Reporting Capability. The aircraft altimetry system should provide an output to the aircraft transponder in accordance with regulations of the approving authority.

(6) Altitude Control Output.

(i) The altimetry system shall provide an output which can be used by an automatic altitude control system to control the aircraft at a commanded altitude. The output may be used either directly or combined with other sensor signals. If SSEC is necessary in order to satisfy the requirements of paragraphs 7c(3) and 7c(4), or 7c(8) of this document, then an equivalent SSEC must be applied to the altitude control output. The output may be an altitude deviation signal, relative to the selected altitude, or a suitable absolute altitude output.

(ii) Whatever the system architecture and SSEC system the difference between the output to the altitude control system and the altitude displayed must be kept to the minimum .

(7) Altimetry System Integrity. During the RVSM approval process it must be verified analytically that the predicted rate of occurrence of undetected altimetry system failures does not exceed 1×10^{-5} per flight hour. All failures and failure combinations whose occurrence would not be evident from cross cockpit checks, and which would lead to altitude measurement/display errors outside the specified limits, need to be assessed against this budget. No other failures or failure combinations need to be considered.

c. Altitude Alert. The altitude deviation warning system should signal an alert when the altitude displayed to the flightcrew deviates from selected altitude by more than a nominal value. For aircraft for which application for type certification or major change in type design is made prior to January 1, 1997, the nominal value shall not be greater than ±300 ft (±90 m). For aircraft for which application for type certification or major change in type design is made after January 1, 1997, the nominal value should not be greater than

±200 ft (±60 m). The overall equipment tolerance in implementing these nominal threshold values should not exceed ±50 ft (±15 m).

d. Automatic Altitude Control System.

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

Note. Aircraft types for which application for Type Certification is made prior to January 1, 1997, which are equipped with automatic altitude control system with flight management system/performance management system inputs which allow variations up to ±130 ft (±40 m) under nonturbulent, nongust conditions do not require retrofit or design alteration.

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

9. AIRWORTHINESS APPROVAL.

a. General. Obtaining RVSM airworthiness approval is a 2 step process. First, the manufacturer or design organization develops the data package through which airworthiness approval should be sought, and submits the package to the appropriate Aircraft Certification Office (ACO) for approval. Once the ACO approves the data package, the operator applies the procedures defined in the package to obtain approval from the FSDO or CMO (as appropriate) to utilize its aircraft to conduct flight in RVSM airspace. Paragraph 9b specifically addresses the data package requirements.

b. Contents of the Data Package.

(1) Scope. As a minimum, the data package should consist of the following items:

(i) A definition of the aircraft group or non-group aircraft to which the data package applies.

(ii) A definition of the flight envelope(s) applicable to the subject aircraft.

(iii) The data needed to show compliance with the requirements of paragraphs 7 and 8.

(iv) The compliance procedures to be used to ensure that all aircraft submitted for airworthiness approval meet RVSM requirements.

(v) The engineering data to be used to ensure continued in-service RVSM approval integrity.

(2) Definition of Aircraft Group. For aircraft to be considered as members of a group for purposes of RVSM approval, they should satisfy all of the following conditions:

(i) Aircraft should have been manufactured to a nominally identical design and be approved by the same Type Certificate (TC), TC amendment, or supplemental TC, as applicable.

Note. *For derivative aircraft it may be possible to utilize the database from the parent configuration to minimize the amount of additional data required to show compliance. The extent of additional data required will depend on the nature of the changes between the parent aircraft and the derivative aircraft.*

(ii) The static system of each aircraft should be installed in a nominally identical manner and position. The same SSE corrections should be incorporated in all aircraft of the group.

(iii) The avionics units installed on each aircraft to meet the minimum RVSM equipment requirements of paragraph 8a should be manufactured to the manufacturer's same specification and have the same part number.

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

(iv) The RVSM data package should have been produced or provided by the airframe manufacturer or design organization.

(3) Definition of Nongroup Aircraft. If an airframe does not meet the conditions of paragraphs 9b(2)(i), 9b(2)(ii), 9b(2)(iii), and 9b(2)(iv) to qualify as a member of a group or is presented as an individual airframe for approval, then it must be considered as a non-group aircraft for the purposes of RVSM approval.

(4) Definition of Flight Envelopes. The RVSM flight envelope is defined as the Mach number, W/δ, and altitude ranges over which an aircraft can be operated in cruising flight within the RVSM airspace (see Appendix 1 for an explanation of W/δ). As noted in

paragraph 7b, the RVSM operational flight envelope for any aircraft may be divided into two zones as defined below:

(i) Full RVSM Envelope:

(A) The Full RVSM Envelope will comprise the entire range of operational Mach number, W/δ, and altitude values over which the aircraft can be operated within RVSM airspace. Table 1 establishes the parameters which should be considered.

Table 1. Full RVSM Envelope Boundaries.

	Lower Boundary is defined by:	Upper Boundary is defined by:
Altitude	• FL 290	The lower of the following • FL 410 • Airplane maximum certified altitude • Altitude limited by: cruise thrust; buffet; other aircraft flight limitations
Mach or Speed	The lower of the following: • Maximum endurance (holding) speed • Maneuver speed	The lower of the following • Mmo/Vmo • Speed limited by: Cruise thrust; buffet; other aircraft flight limitations
Gross Weight	• The lowest gross weight compatible with operation in RVSM airspace	• The highest gross weight compatible with operation in RVSM airspace

(ii) Basic RVSM Envelope:

(A) The boundaries for the Basic RVSM Envelope are the same as those for the Full RVSM Envelope except in regard to the upper Mach boundary.

(B) For the Basic RVSM Envelope, the upper Mach boundary may be limited to a range of airspeeds over which the aircraft group can reasonably be expected to operate most frequently. This boundary should be declared for each aircraft group by the manufacturer or design organization. It may be defined as equal to the upper Mach/airspeed boundary defined for the Full RVSM Envelope or a specified lower value. This lower value should not be less than the Long Range Cruise Mach Number plus .04 Mach unless limited by available cruise thrust, buffet, or other aircraft flight limitations:

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

(5) Data Requirements. The data package should contain data sufficient to substantiate that the accuracy standards of paragraph 7 are met.

(i) General.

(A) ASE will generally vary with flight condition. The data package should provide coverage of the RVSM envelope sufficient to define the largest errors in the Basic and Full RVSM envelopes. Note that in the case of group approval the worst flight condition may be different for each of the requirements of paragraph 7c(3) and 7c(4), and each should be evaluated.

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

(1) Precision tracking radar in conjunction with pressure calibration of atmosphere at test altitude.

(2) Trailing cone.

(3) Pacer aircraft.

(4) Any other method acceptable to the FAA or approving authority.

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

(ii) Altimetry System Error Budget. It is implicit in the intent of paragraph 7c, for group approvals and for non-group approvals, that a trade may be made between the various error sources which contribute to ASE (as noted in Appendix 2). This document does not specify separate limits for the various error sources which contribute to the mean and variable components of ASE as long as the overall ASE accuracy requirements of paragraph 7c are met. For example, in the case of group approval, the smaller the mean of the group and the more stringent the avionics standard, the larger the available allowance for SSE variations. In all cases the trade-off adopted should be presented in the data package in the form of an error budget which includes all significant error sources. This is discussed in more detail in the following sections and the discussion of altimetry system error sources provided in Appendix 2.

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

(iv) Groups of Aircraft. Where approval is sought for an aircraft group, the data package must be sufficient to show that the requirements of paragraph 7c(3) and 7c(4) are met. Because of the statistical nature of these requirements, 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 change in the mean and variability based on geometric inspections and bench test or any other method acceptable to the approving authority. In the case of derivative aircraft it may be possible to utilize data from the parent as part of the data base. (An example would be the case of a fuselage stretch where the only difference in mean ASE between groups could be reliably accounted for by analytical means.)

(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 3SD. For other error sources (especially larger ones) a more comprehensive assessment may be required; this is especially true for airframe error sources where "specification" values of ASE contribution may not have been previously established.

(C) In many cases one or more of the major ASE error sources will be aerodynamic in nature (such as variations in the aircraft surface contour in the vicinity of the static pressure source). If evaluation of these errors is based on geometric measurements, substantiation should be provided that the methodology used is adequate to ensure compliance. An example of the type of data which could be used to provide this substantiation is provided in figure 3-2 of Appendix 3.

(D) An error budget should be established to ensure that the standards of paragraphs 7c(3) and 7c(4) are met. As noted in 9b(5)(i)(A), the worst flight condition may be different for each of these standards and therefore the component error values may also be different.

(E) In showing compliance with the overall requirements, the component error sources should be combined in an appropriate manner. In most cases this will involve the algebraic summation of the mean components of the errors, root-sum-square (rss) combination of the variable components of the errors, and summation of the rss value with the absolute value of the overall mean. (Care should be taken that only variable component error sources which are independent of each other are combined by rss.)

(F) The methodology described above for group approval is statistical in nature. This is the result of the statistical nature of the risk analysis and the resulting statistical statements of Appendix 6, paragraphs 5a and 5b. In the context of a statistical method, the statements of Appendix 6, paragraph 5c required reassessment. This item states that "each individual aircraft in the group shall be built to have ASE contained within ±200 feet". 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 200 ft. Such an interpretation would be unduly onerous considering that the risk analysis allows for a small proportion of aircraft to exceed 200 ft. However, it is accepted that if any aircraft is identified as having an error exceeding ±200 ft then it should receive corrective action.

(v) Nongroup Aircraft. Where an aircraft is submitted for approval as a nongroup aircraft, the data should be sufficient to show that the requirements of paragraph 7c(8) are met. The data package should specify how the ASE budget has been allocated between residual SSE and avionics error. The operator and the FAA should agree on what data is needed to satisfy approval requirements. The following data should be established:

(A) Precision flight test calibration of the aircraft to establish its ASE or SSE over the RVSM envelope should be required. Flight calibration should be performed at points in the flight envelope(s) as agreed by the certifying authority. One of the methods prescribed in paragraph 9b(5)(i)(B) 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 certifying 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 indicating the largest allowable errors will be presented.

(D) Using paragraphs 9b(5)(v)(A), 9b(5)(v)(B), and 9b(5)(v)(C) demonstrate that the requirements of paragraph 7c(8) are met. If subsequent to aircraft approval for RVSM operation avionic units which 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.

(6) Compliance Procedures. The data package must include a definition of the procedures, inspections/tests and limits which will be used to insure that all aircraft approved against the data package "conform to type," that is all future approvals, whether of new build or in-service aircraft, meet the budget allowances developed according to paragraph 9b(5)(ii). The budget allowances will be established by the data package and include a methodology that allows for tracking the mean and SD for new build aircraft. Compliance requirements must be defined for each potential source of error. A discussion of error sources is provided in Appendix 2. Examples of compliance procedures are presented in Appendix 3.

(7) Where an operating restriction has been adopted (see paragraph 7c(4)(iii)), the package should contain the data and information necessary to document and establish that restriction.

(8) Continued Airworthiness.

(i) The following items should be reviewed and updated as appropriate to include the effects of RVSM implementation:

(A) The Structural Repair Manual with special attention to the areas around the static source, angle of attack sensors and doors if their rigging can affect airflow around the previously mentioned sensors.

(B) The MMEL.

(ii) The data package should include descriptions of any special procedures which are not covered in paragraph 9b(8)(i) but may be needed to insure continued compliance with RVSM requirements as follows:

(A) For nongroup aircraft where airworthiness approval has been based on flight test, the continuing integrity and accuracy of the altimetry system shall be demonstrated by periodic ground and flight tests of the aircraft and its altimetry system at periods to be agreed with the approving authority. However, alleviation of the flight test requirement may be given if it can be adequately demonstrated that the relationship between any subsequent airframe/system degradation and its effects on altimetry system accuracy is understood and adequately compensated/corrected for.

(B) To the extent possible, in-flight defect reporting procedures should be defined to facilitate identification of altimetry system error sources. Such procedures could cover acceptable differences between primary and alternate static sources, and others as appropriate.

(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.

c. Data Package Approval. All necessary data should be submitted to the appropriate ACO for action.

d. RVSM Airworthiness Approval. The approved data package should be used by the operator to demonstrate compliance with RVSM performance standards.

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

10. CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS).

a. General.

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

(2) Each person or operator should demonstrate that adequate maintenance facilities are available to ensure continued compliance with the RVSM maintenance requirements.

b. Maintenance Program Approval Requirements. Each operator requesting RVSM operational approval should submit a maintenance and inspection program which includes any maintenance requirements defined in the approved data package (paragraph 9) as part of a continuous airworthiness maintenance program approval or an equivalent program approved by the FAA. Although air carriers operating aircraft subject to a continuous airworthiness maintenance program do not have to comply with the provisions of FAR Section 91.411 pertaining to altimeter system and altitude reporting equipment test and inspections, an effective maintenance and inspection program will, typically, incorporate these provisions as a requirement for maintenance program approval.

c. Maintenance Documents Requirements. The following items should be reviewed as appropriate for RVSM maintenance approval:

(1) Maintenance Manuals.

(2) Structural Repair Manuals.

(3) Standards Practices Manuals.

(4) Illustrated Parts Catalogs.

(5) Maintenance Schedule.

(6) MMEL/MEL.

d. Maintenance Practices.

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

(i) All RVSM equipment should be maintained in accordance with the component manufacturer's maintenance requirements and the performance requirements outlined in the approved data package.

(ii) Any modification, repair, or design change which in any way alters the initial RVSM approval, should be subject to a design review by persons approved by the approving authority.

(iii) Any maintenance practices which may affect the continuing RVSM approval integrity, e.g., the alignment of pitot/static probes, dents, or deformation around static plates, should be referred to the approving authority or persons delegated by the authority.

(iv) Built-in Test Equipment (BITE) testing is not an acceptable basis for system calibrations, (unless it is shown to be acceptable by the airframe manufacturer with the approval authorities agreement) and should only be used for fault isolation and troubleshooting purposes.

(v) Some aircraft manufacturers have determined that the removal and replacement of components utilizing quick disconnects and associated fittings, when properly connected, will not require a leak check. While this approach may allow the aircraft to meet static system certification standards when properly connected, it does not always ensure the integrity of the fittings and connectors, nor does it confirm system integrity during component replacement and reconnections. Therefore, a system leak check or visual inspection should be accomplished any time a quick disconnect static line is broken.

(vi) Airframe and static systems should be maintained in accordance with the airframe manufacturer's inspection standards and procedures.

(vii) To ensure the proper maintenance of airframe geometry for proper surface contours and the mitigation of altimetry system error, surface measurements or skin waviness checks should be made if needed to ensure adherence to the airframe manufacturer's RVSM tolerances. These tests and inspections should be performed as established by the airframe manufacturer. These checks should also be performed following repairs, or alterations having an effect of airframe surface and airflow.

(viii) The maintenance and inspection program for the autopilot should ensure continued accuracy and integrity of the automatic altitude control system to meet the height-keeping standards for RVSM operations. This requirement will typically be satisfied with equipment inspections and serviceability checks.

(ix) Where the performance of existing equipment is demonstrated as being satisfactory for RVSM approval, it should be verified that the existing maintenance practices are also consistent with continued RVSM approval integrity. Examples of these are:

(A) Altitude alert.

(B) Automatic altitude control system

(C) ATC altitude reporting equipment (transponders FAR 91.215)

(D) Altimetry systems.

e. <u>Maintenance Practices for Noncompliant Aircraft</u>. Those aircraft positively identified as exhibiting height-keeping performance errors which require investigation as specified in paragraph 11i(1) should not be operated in airspace where RVSM is applied until the following actions have been taken:

(1) The failure or malfunction is confirmed and isolated by maintenance action and,

(2) Corrective action is carried out as required to comply with paragraph 9b(5)(iv)(F) and verified to ensure RVSM approval integrity.

f. Maintenance Training Requirements. It is expected that new training requirements will be introduced by the RVSM approval processes. Areas that may need to be highlighted for initial and recurrent training of shop and line personnel are:

(1) Aircraft geometric inspection techniques.

(2) Test equipment calibration/usage techniques.

(3) Any special documentation or procedures introduced by RVSM approval.

g. Test Equipment.

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

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

(i) Definition of required test equipment accuracy.

(ii) Regular calibrations of test equipment traceable to a master inhouse standard. Determination of calibration interval should be a function of the stability of the test equipment. The calibration interval should be established on the basis of historical data so that degradation is small in relation to the required accuracy.

(iii) Regular audits of calibration facilities both inhouse and outside.

(iv) Adherence to acceptable shop and line maintenance practices.

(v) Procedures for controlling operator errors and unusual environmental conditions which may affect calibration accuracy.

11. OPERATIONAL APPROVAL.

a. Purpose and Organization. Paragraph 6 describes in general the administrative process which an operator should follow to receive approval to operate an aircraft in RVSM airspace. Paragraph 11 is intended to provide detailed guidance on the content of operational programs, practices, and procedures. It also describes specifically the steps in the operational approval process: application for authority, FAA evaluation of this application, and granting of approval to operate. Appendices 4 and 5 are related to this paragraph and contain essential information for operational programs.

* b. General. The FAA should ensure that each operator can maintain high levels of height-keeping performance.

(1) The FAA should be satisfied that operational programs are adequate. Flightcrew training as well as operations manuals should be evaluated. Approval should be granted for each individual operator.

(2) Approval should be granted for each individual aircraft group and each individual aircraft to be used by the operator in RVSM operations. Each aircraft should receive airworthiness approval in accordance with paragraph 9 prior to being approved for use by the operator. (Aircraft group is defined in paragraph 9b(2).

* (3) Aircraft Approval for Worldwide RVSM Operations. Aircraft that have been approved for RVSM can be used in RVSM operations worldwide. This includes RVSM operation in continental areas such as Europe and the U.S. when RVSM is implemented in those areas. Aircraft equipage and altitude-keeping performance requirements were developed using the highest density traffic counts in the world so that aircraft could receive one-time approval for worldwide operations.

* (4) Operational Approval for New RVSM Areas of operation. Operators that are starting RVSM operations in an RVSM area of operations that is new to them should ensure that their RVSM programs incorporate any operations or continued airworthiness requirements unique to the new are of operations. (See Paragraph 11g for information on the form of RVSM authority for new areas of operations).

c. Pre-application Meeting. A pre-application meeting should be scheduled between the operator and the CMO or FSDO. The intent of this meeting is to inform the operator of FAA expectations in regard to approval to operate in a RVSM environment. The content of the operator RVSM application, FAA review and evaluation of the application, validation flight requirements, and conditions for removal of RVSM authority should be basic items of discussion.

* d. Content of Operator RVSM Application. The following paragraphs describe the material which an operator applying for RVSM authority should provide to the FAA for review and evaluation at least 60 days prior to the intended start of RVSM operations. Part 121, 125, and 135 operators applying for authority to conduct operations in an RVSM area

of operations that is new to them may modify the application content to address those items unique to the new area of operations. Part 91 operators, and Part 125 operators holding a deviation that allows operation under Part 91 that have obtained an LOA for RVSM operations in the North Atlantic should contact the appropriate FSDO to determine the LOA requirements (if any) for a new RVSM area of operations. (See Paragraph 11g).

(1) Airworthiness Documents. Sufficient documentation should be available to show that the aircraft has been approved by appropriate airworthiness authorities.

* (i) In-service aircraft. Documents that contain the inspections and/or modifications that are required to make an in-service aircraft RVSM compliant can take the form of approved Service Bulletins, Aircraft Service Changes, Supplemental Type Certificates or any other format the FAA finds acceptable.

* (ii) In-production or New-production aircraft. For such aircraft, statements of eligibility to conduct RVSM operations can be included in the Airplane Flight Manual. Also, Type Certification Data Sheets can be used to show RVSM eligibility by describing RVSM related avionics configurations and continued airworthiness criteria or providing reference to FAA approved documentation in the form of a report. Eligibility can be shown in any other format found acceptable to the FAA.

(2) Description of Aircraft Equipment. The applicant should provide a configuration list which details all components and equipment relevant to RVSM operations. (Paragraph 8 discusses equipment for RVSM operations).

* (3) Operations Training Programs and Operating Practices and Procedures. Practices and procedures in the following areas should be standardized using the guidelines of Appendix 4: flight planning, preflight procedures at the aircraft for each flight, procedures prior to RVSM airspace entry, inflight procedures, and flightcrew training procedures. Appendix 4, paragraph 7 contains special emphasis items for flightcrew training. Also, pilots and, where applicable, dispatchers should be knowledgeable on contingency and other procedures unique to specific areas of operation. (See the appendices for guidance on such procedures. Appendix 5, for example, contains guidance on oceanic contingency procedures).

* (i) FAR Part 121, 125 and 135 Operators. Such operators should submit training syllabi and other appropriate material to the FAA to show that the operating practices and procedures and training items related to RVSM operations are incorporated in initial and, where warranted, recurrent training programs. (Training for dispatchers should be included, where appropriate).

* (ii) FAR Part 91 Operators and Part 125 Operators holding a deviation that allows operation under Part 91. These operators should show the FAA that pilot knowledge of RVSM operating practices and procedures will be adequate to warrant granting of approval to conduct RVSM operations. The following are acceptable means for the operator to show the FAA that its pilots will have adequate knowledge of the RVSM operating

practices and procedures contained in Appendices 4 and 5: the FAA may accept training center certificates without further evaluation; may evaluate a training course prior to accepting a training certificate; may accept a statement in the operator's application that the operator will ensure that its pilots will be knowledgeable on RVSM procedures contained in Appendices 4 and 5; or may accept a statement by the operator that it has or will conduct an in-house training program.

* (4) Operations Manuals and Checklists. The appropriate manuals and checklists should be revised to include information/guidance on standard operating procedures detailed in Appendix 4 and in the appendices that address area of operations unique procedures (e.g., Appendix 5). Appropriate manuals should include a statement of the airspeeds, altitudes and weights considered in RVSM aircraft approval to include identification of any operations restrictions established for that aircraft group (see paragraph 7c(4)(iii)). Manuals and checklists should be submitted for FAA review as part of the application process.

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

(6) Minimum Equipment List. A minimum equipment list (MEL), adopted from the master minimum equipment list (MMEL), should include items pertinent to operating in RVSM airspace.

(7) Maintenance. The operator should submit a maintenance program for approval in accordance with paragraph 10 at the time the operator applies for operational approval.

* (8) Plan for participation in Verifications/Monitoring Programs. The operator should provide a plan for participation in the verification/monitoring program. This program should normally entail a check of at least a portion of the operator's aircraft by an independent height-monitoring system. Guidance on monitoring programs for specific areas of operation can be found on the FAA RVSM website. It can be accessed by typing www.faa.gov and clicking on RVSM and Go in the Quick Jump menu. (See paragraph 11h for further discussion of verification/monitoring programs).

e. FAA Review and Evaluation of Applications.

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

(2) When all the airworthiness and operational requirements of the application are met, the authority will proceed with the approval process.

f. Validation Flight(s) for Part 121 and 135 operators. In some cases, the review of the RVSM application and programs may suffice for validation purposes. However, the final step of the approval process may be the completion of a validation flight. The FAA may accompany the operator on a flight through airspace where RVSM is applied to verify that operations and maintenance procedures and practices are applied effectively. If the performance is adequate, operational approval for RVSM airspace should be granted. If performance is not adequate, then approval should be delayed.

g. Form of Authorizing Documents.

* (1) FAR Part 121, Part 125, and Part 135 Operators. Approval to operate in RVSM airspace should be granted through the issuance of an operations specifications paragraph from Part B (En route Authorizations, Limitation, and Procedures) and Part D (Aircraft Maintenance). Each aircraft type group for which the operator is granted authority should be listed in OpSpecs. Approval to conduct RVSM operations in an RVSM area of operations that is new to the operator should be granted by adding the part B RVSM OpSpecs paragraph number to the appropriate area of operations in the Part B paragraph: Authorized Areas of En Route Operation. Limitations and Provisions.

(2) FAR Part 91 Operators and Part 125 operators holding a deviation to operate under Part 91. These operators should be issued a letter of authorization (LOA) when the approval process has been completed. This LOA should be reissued on a biennial basis. Operators that have obtained an LOA for RVSM operations in the North Atlantic should contact the appropriate FSDO to determine the LOA requirements (if any) for an RVSM area of operation that is new to them.

h. Verification/Monitoring Programs. A program to monitor or verify aircraft height-keeping performance is considered a necessary element of RVSM implementation for at least the initial area where RVSM is implemented. Verification/Monitoring programs have the primary objective of observing and evaluating aircraft height-keeping performance to gain confidence that airspace users are applying the airplane/operator approval process in an effective manner and that an equivalent level of safety will be maintained when RVSM is implemented. It is anticipated that the necessity for such programs may be diminished or possibly eliminated after confidence is gained that RVSM programs are working as planned.

Note: A height-monitoring system based on Global Positioning Satellites or an earth-based system may fulfill this function.

i. Conditions for Removal of RVSM Authority.

(1) The incidence of height-keeping errors which can be tolerated in an RVSM environment is very small. It is incumbent upon each operator to take immediate action to rectify the conditions which caused the error. The operator should also report the event to the FAA within 72 hours with initial analysis of causal factors and measures to prevent further events. The requirement for follow up reports should be determined by the FAA. Errors which should be reported and investigated are: TVE equal to or greater than ±300 ft

(±90 m), ASE equal to or greater than ±245 ft (±75 m), and AAD equal to or greater than ±300 ft (±90 m).

(2) Height-keeping errors fall into two broad categories: errors caused by malfunction of aircraft equipment and operational errors. An operator which consistently commits errors of either variety may be required to forfeit authority for RVSM operations. If a problem is identified which is related to one specific aircraft type, then RVSM authority may be removed for the operator for that specific type.

(3) The operator should make an effective, timely response to each height-keeping error. The FAA may consider removing RVSM operational approval if the operator response to a height-keeping error is not effective or timely. The FAA should also consider the operator's past performance record in determining the action to be taken. If an operator shows a history of operational and/or airworthiness errors, then approval may be removed until the root causes of these errors are shown to be eliminated and RVSM programs and procedures are shown to be effective. The FAA will review each situation on a case-by-case basis.

APPENDIX 1. EXPLANATION OF W/δ

1. Paragraph 9(b)(4) describes the range of flight conditions over which conformity to the ASE rules must 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 vs. 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 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.

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

δ = ambient pressure at flight altitude divided by sea level standard pressure of 29.92126 inches Hg
W/δ = Weight over Atmospheric Pressure Ratio
C_L = Lift Coefficient
M = Mach Number
S_{REF} = Reference Wing Area

4. As a result, the flight envelope 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.

APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

1. INTRODUCTION. Paragraph 9b(5)(ii) states that an error budget must be established and presented in the approval data package. The requirements for this error budget are discussed in some detail in paragraph 9b(5)(iii) through 9b(5)(v) for group and non-group aircraft. The purpose of this appendix is to provide guidance to help ensure that all of the potential error sources are identified and included in the error budget for each particular model.

2. OBJECTIVE OF ASE BUDGET.

a. 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 requirements. 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 requirements.

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

c. 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.

a. 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 which can occur, although different system architectures may combine the components in slightly different ways.

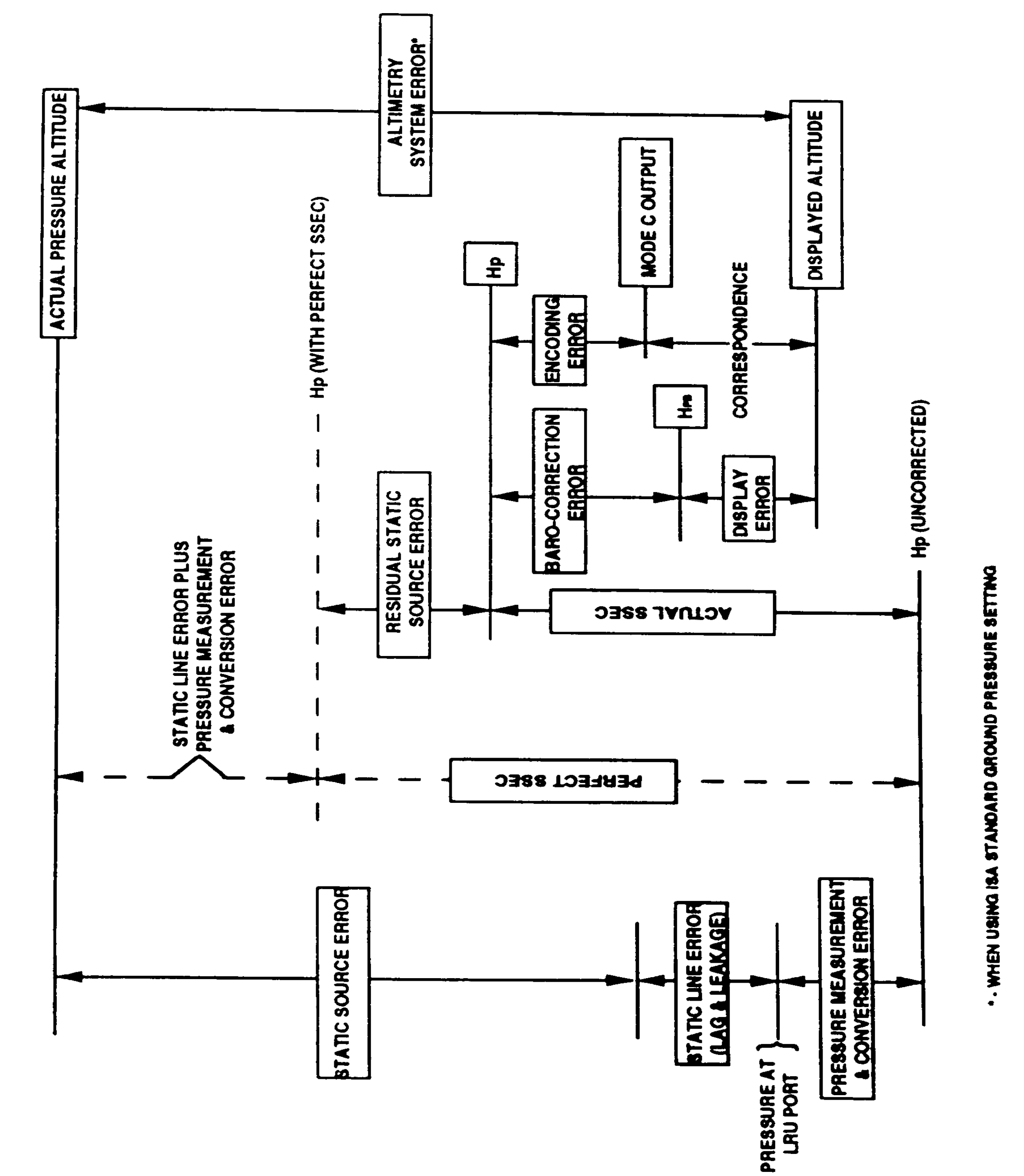
(1) The "Actual Altitude" is the pressure altitude corresponding to the undisturbed ambient pressure.

(2) "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.

(3) "Static Line Error" is any difference in pressure along the length of the line.

APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

Figure 2-1 ASE and Its Components



APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

(4) "Pressure Measurement and Conversion Error" is the error associated with the processes of transducing 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 (Hp) was calculated.

(5) "Perfect SSEC" would be that correction which compensated exactly for the SSE actually present at any time. If such a correction could be applied, then the resulting value of Hp 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.

(6) "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.

(7) 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 which 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 which 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.

b. <u>Components</u>. The altimetry system errors presented in table 2-1 and described in paragraph 3a are discussed below in greater detail.

(1) <u>Static Source Error</u>. The component parts of SSE are presented in table 2-1, with the factors which control their magnitude.

(i) 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 which are functions of Mach. It includes the effect of any aerodynamic compensation which may have been incorporated in the design once it has been determined, the reference SSE is fixed for the single aircraft or group, although it may be revised in the light of subsequent data.

(ii) The test techniques used to derive the reference SSE will have some measurement uncertainty associated with them, even though known instrumentation errors

APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

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.

(iii) 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.

(2) Residual Static Source Error.

(i) The components and factors are presented in Table 2-2. 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 which would correct the reference value exactly, components 2(a), (b) and (c) from Table 2-2.

(ii) There will generally be a difference between the SSEC which would exactly compensate the reference SSE, and the SSEC which 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 which cause a particular set of avionics to apply an actual SSEC which differs from its design value.

(iii) 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.

APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

Table 2-1. Static Source Error
(Cause: Aerodynamic Disturbance to Free-Stream Conditions)

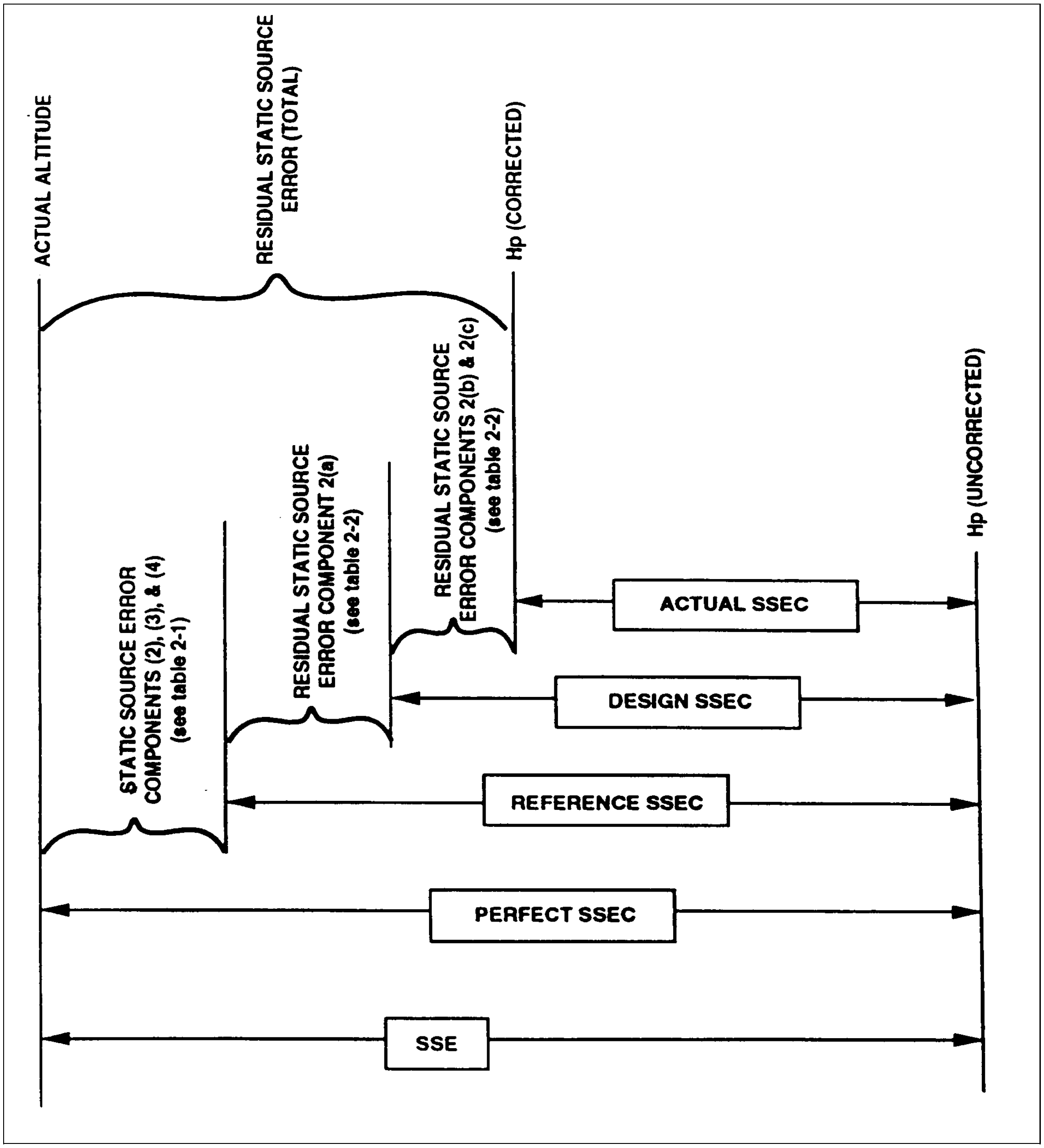
Factors	Error Components
Airframe Effects Operating Condition $(M, Hp, \propto, \beta)$ Geometry: shape of airframe location of static sources variations of surface contour near the sources variations in fit of nearby doors, skin panels or other items Probe/Port Effects Operating Condition $(M, Hp, \propto, \beta)$ Geometry: shape of probe/port manufacturing variations installation variations	1) Reference SSE values from flight calibration measurements. 2) Uncertainty of flight calibration measurements. 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) Static Source Error Components (2), (3), and (4) from table 2-1 PLUS 2a) Approximation in fitting design SSEC to flight calibration reference SSE. 2b) Effect of production variability (sensors and avionics) on achieving design SSEC. 2c) Effect of operating environment (sensors and avionics) on achieving design SSEC.

APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

Figure 2-2 SSE/SSEC Relationships for ASE where Static Line, Pressure Measurement and Conversion Errors are Zero



APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

(iv) Factors which create variability of SSE relative to the reference characteristic must be accounted for in two ways. Firstly, as noted for the SSE itself in table 2-1, and secondly for its effect on the application of SSEC as in factor 2(a)(i) of table 2-2. Similarly the static pressure measurement error must be accounted for in two separate ways. The main effect will be via the "pressure measurement and conversion" component, but a secondary effect will be via Factor 2(a)(ii) Table 2-2.

(3) Static Line Error. Static line errors arise from leaks and pneumatic lags. In level cruise these can be made negligible for a system which is correctly designed and correctly installed.

(4) Pressure Measurement and Conversion Error.

(i) The functional elements are static pressure transduction, which may be mechanical, electromechanical or solid-state, and the conversion of pressure signal to pressure altitude.

(ii) The error components are:

(A) calibration uncertainty;

(B) nominal design performance;

(C) unit to unit manufacturing variations; and

(D) effect of operating environment.

(iii) 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.

(iv) It is particularly important to ensure that the specified environmental performance is adequate for the intended application.

APPENDIX 2. ALTIMETRY SYSTEM ERROR COMPONENTS

(5) Baro-Setting Error. This is defined as the difference between the value displayed and the value applied within the system. For RVSM operation the value displayed should always be ISA standard ground pressure, but setting mistakes, although part of TVE, are not components of ASE.

(i) The components of Baro-Setting Error are:

(A) resolution of setting knob/display ("Setability");

(B) transduction of displayed value; and

(C) application of transduced value.

(ii) The applicability of these factors and the way that they combine depends on the particular system architecture.

(iii) For systems in which the display is remote from the pressure measurement function there may be elements of the transduction and/or application or transduced value error components which arise from the need to transmit and receive the setting between the two locations

(6) Display Error. The cause is imperfect conversion from altitude signal to display. The components are:

(i) conversion of display input signal;

(ii) graticule/format accuracy, and

(iii) readability.

(7) In self-sensing altimeters the first of these would normally be separate from the pressure measurement and conversion error

APPENDIX 3: ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

1. The requirements for the data package are discussed in general terms in paragraph 9b. It is stated, in paragraph 9b(5)(iv)(C) that the methodology used to establish the static source error must be substantiated. It is further stated in paragraph 9b(6) that procedures be established to ensure conformity of newly manufactured airplanes. There may be many ways of satisfying these requirements; two examples are discussed below.

2. Example 1.

a. One process for showing compliance with RVSM requirements is shown in Figure 3-1. Figure 3-1 illustrates that 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 requirements. 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 manufacturer and agreed to by the approving authority. The data generated by N inspections and M flight calibrations shall be used to track the mean and 3 SD values to insure continued compliance of the model with the requirements 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.

b. 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 airplanes 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.

c. 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.

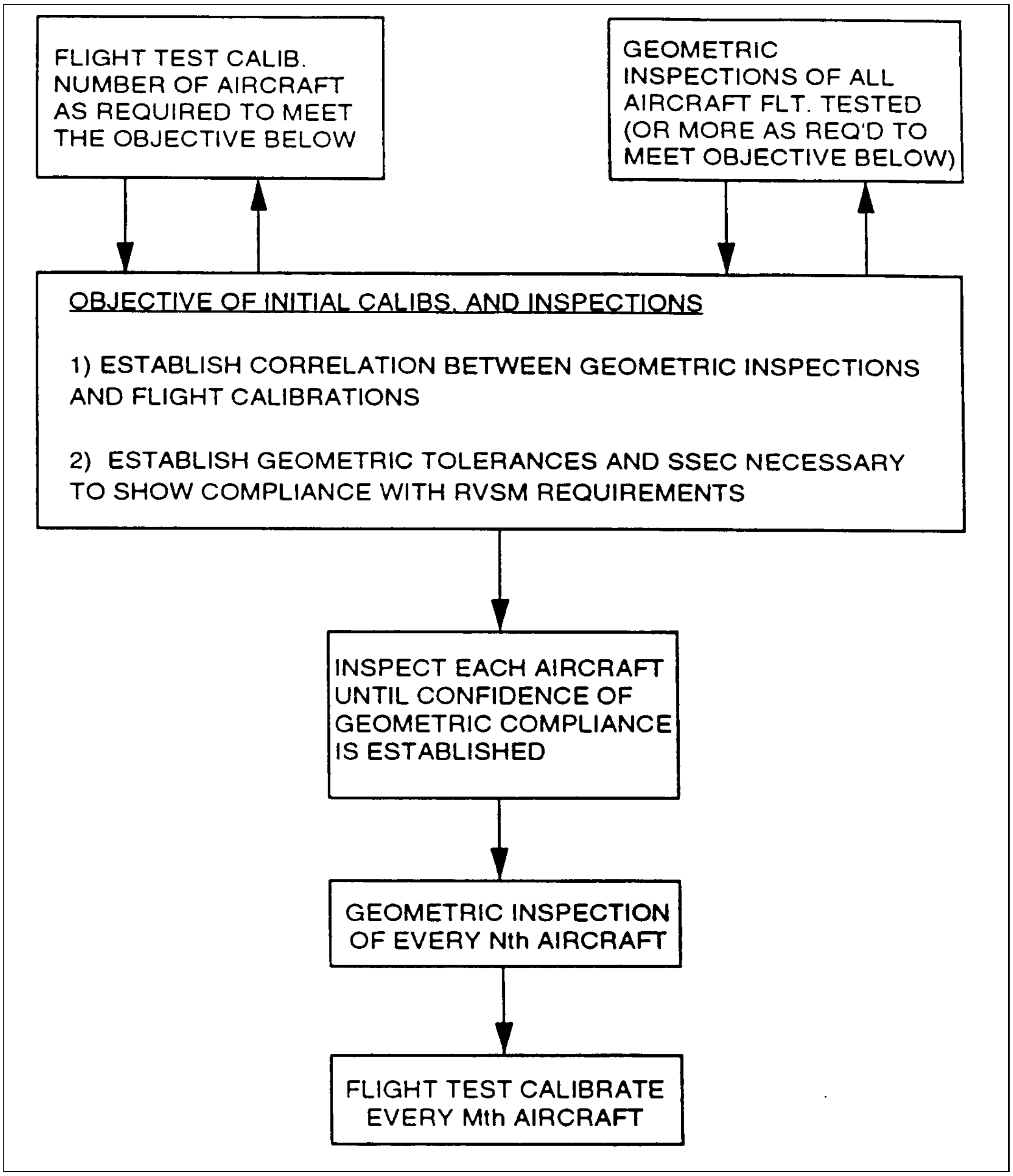
a. Figure 3-3 illustrates that flight test calibrations should be performed on a given number of aircraft and consistency rules for air data information between all concerned systems verified. Geometric tolerances and SSEC should be established to satisfy the requirements. A correlation should be established between the design tolerances and the consistency rules. For aircraft being manufactured, air data information for all aircraft should be checked in term of consistency in cruise conditions and every Mth aircraft should be calibrated, where M is determined by the manufacture and agreed to by the approving authority. The data generated by the M flight calibrations should be used to

APPENDIX 3: ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

track the mean and 3SD values to ensure continued compliance of the group with the requirements of paragraph 7.

APPENDIX 3: ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

Figure 3-1 Process for Showing Initial and Continues Compliance of Airframe Static Pressure System



APPENDIX 3: ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

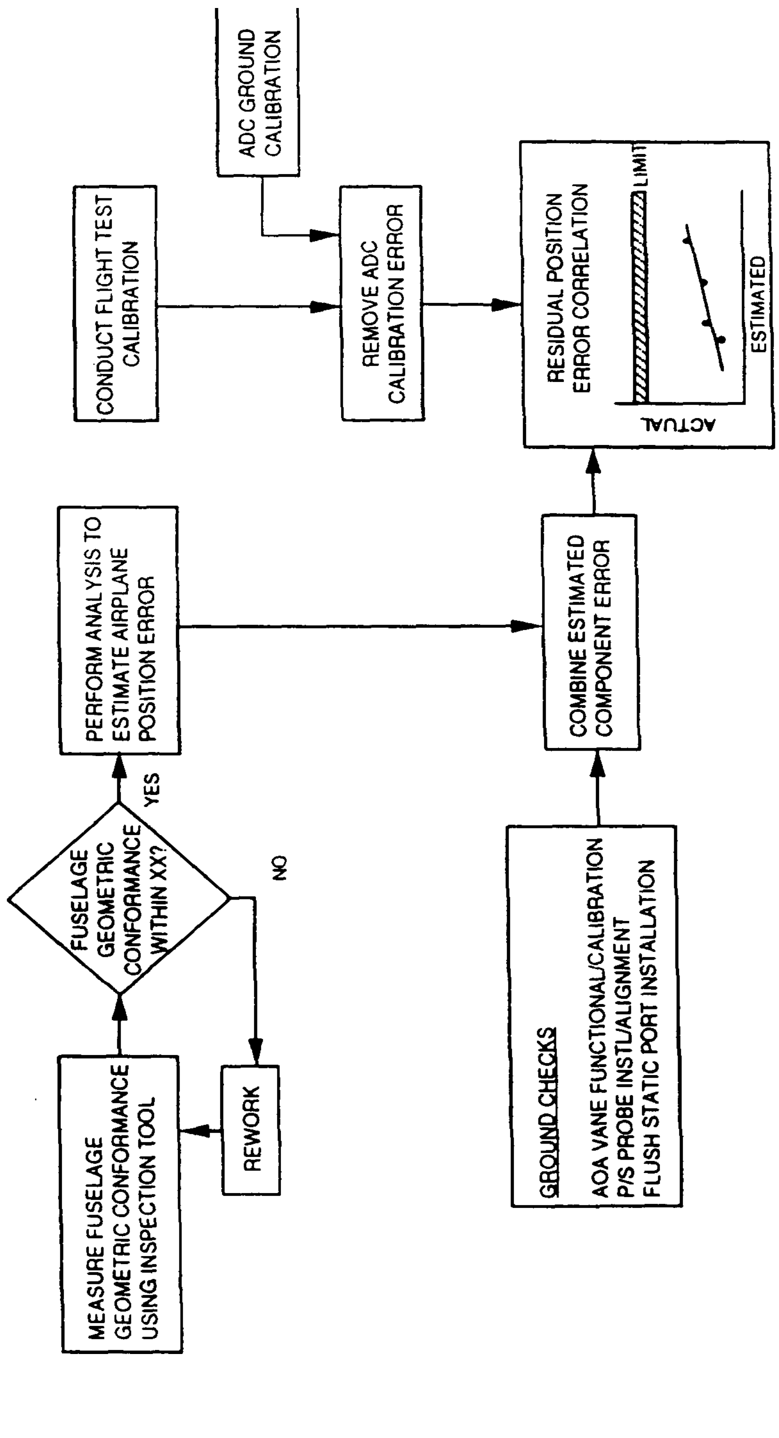
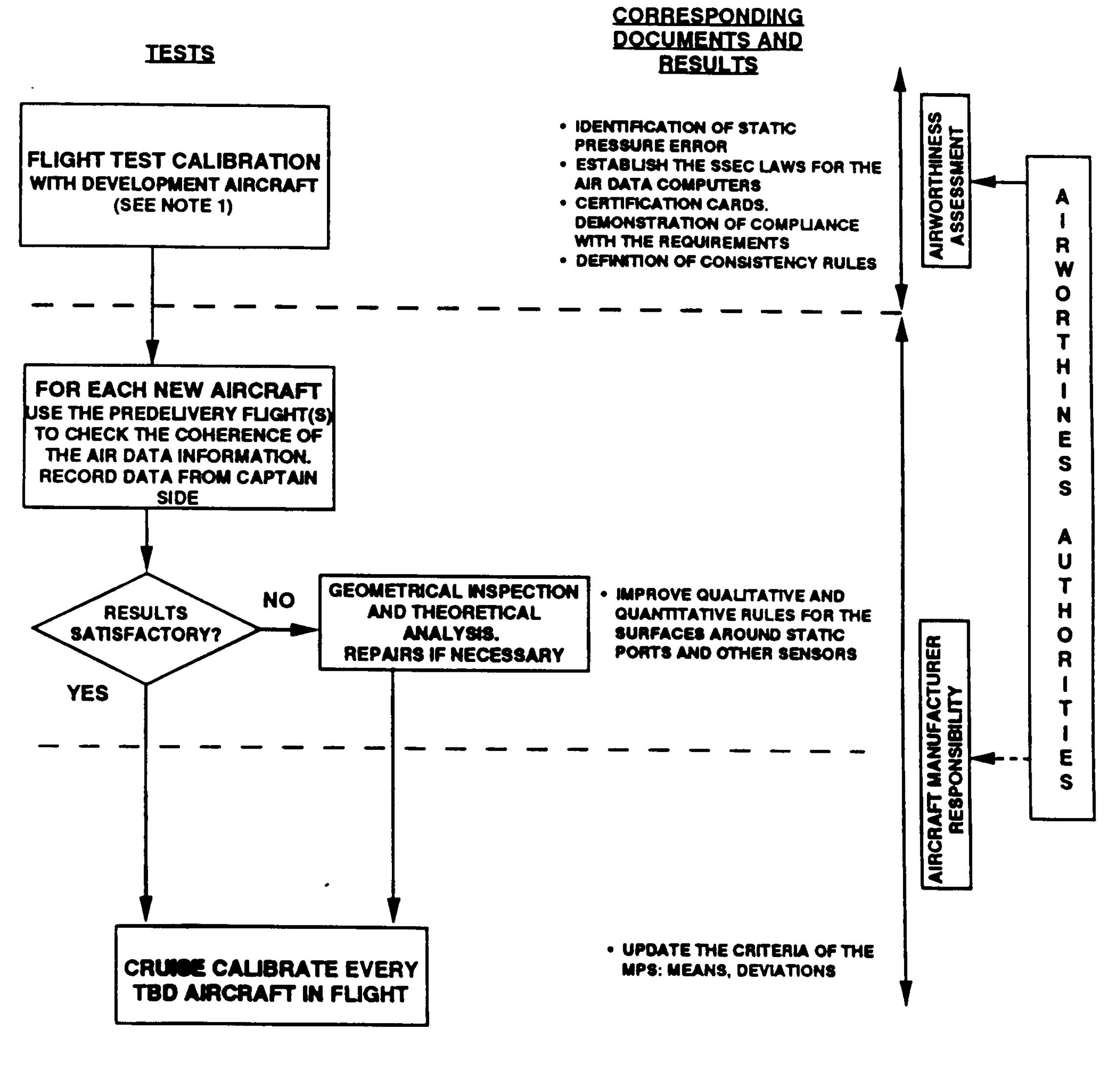


Figure 3-2. Compliance Demonstration Ground-to-flight Test Correlation Process Example.

APPENDIX 3: ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

Figure 3-3 Process for Showing Initial and Continued Compliance of Airframe Static Pressure Systems for In-Service and New Model Aircraft



NOTE1: THE FLIGHT TEST INSTALLATION CHOSEN TO GET THE CALIBRATION DATA SHALL HAVE AN ACCURACY COMPATIBLE WITH THE LEVEL OF PERFORMANCE TO BE DEMONSTRATED AND AN ANALYSIS OF THIS ACCURACY SHALL BE PROVIDED. ANY POSSIBLE DEGRADATION OF THIS ACCURACY SHALL BE MONITORED AND CORRECTED DURING THE FLIGHT TEST PERIOD.

APPENDIX 4. TRAINING PROGRAMS AND OPERATING PRACTICES AND PROCEDURES

1. Introduction. The following items (detailed in paragraphs 2 through 7) should be standardized and incorporated into training programs and operating practices and procedures. Certain items may already be adequately standardized in existing operator programs and procedures. New technologies may also eliminate the need for certain crew actions. If this is the case, then the intent of this guidance can be considered to be met.

Note. The document has been written for use by a wide variety of operator types (FAA Part 91 to Part 121) and therefore, certain items have been included for purposes of clarity and completeness.

2. Flight Planning. During flight planning, the flightcrew and dispatchers, if applicable, should pay particular attention to conditions which may affect operation in RVSM airspace. These include, but may not be limited to:

a. verifying that the aircraft is approved for RVSM operations.

* b. annotating the flight plan to be filed with the Air Traffic Service Provider to show that the aircraft and operator are approved for RVSM operations. (In North Atlantic Minimum Navigation Performance (NAT MNPS) and Pacific oceanic airspace, block 10 (Equipment) of the ICAO flight plan should be annotated with the letter "W" to show RVSM approval).

c. reported and forecast weather conditions on the route of flight;

d. minimum equipment requirements pertaining to height-keeping systems; and

e. If required for the specific aircraft group; accounting for any aircraft operating restrictions related to RVSM airworthiness approval. (See paragraph 7c(4)(iii)).

3. Preflight procedures at the aircraft for each flight. The following actions should be accomplished during preflight:

a. Review maintenance logs and forms to ascertain 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 in the vicinity of each static source and any other component that affects altimetry system accuracy (this check may be accomplished by a qualified and authorized person other than the pilot, e.g., a flight engineer or maintenance personnel);

APPENDIX 4. TRAINING PROGRAMS AND OPERATING PRACTICES AND PROCEDURES

* c. Before takeoff, the aircraft altimeters should be set to the local altimeter (QNH) setting and should display a known elevation (e.g., field elevation) within the limits specified in aircraft operating manuals. The difference between the known elevation and the elevation displayed on the altimeters should not exceed 75 ft. The two primary altimeters should also agree within limits specified by the aircraft operating manual. An alternative procedure using QFE may also be used;

d. Before take-off, equipment required for flight in RVSM airspace should be operational, and 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.

Note. Dual equipment requirements for altitude-control systems may 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. Should any of the required equipment fail prior to the aircraft entering RVSM airspace, the pilot should request a new clearance so as to avoid flight in this airspace;

Note. Operating Transponder. The operator should ascertain the requirement for an operational transponder in each RVSM area where operations are intended. The operator should also ascertain the transponder requirements for transition areas adjacent to RVSM airspace. Appendix 5, paragraph 9 discusses transponder failure for RVSM transition areas.

APPENDIX 4. TRAINING PROGRAMS AND OPERATING PRACTICES AND PROCEDURES

5. In-flight Procedures. The following policies should be incorporated into flight crew training and procedures:

a. Flight crews should comply with aircraft operating restrictions (if required for the specific aircraft group) related to RVSM airworthiness approval. (See paragraph 7c(4)(iii)).

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

c. In level cruise it is essential that the aircraft is flown at the CFL. This requires that particular care is taken to ensure that ATC clearances are fully understood and followed. Except in contingency or emergency situations, the aircraft should not intentionally depart from CFL without a positive clearance from ATC;

d. During cleared transition between levels, the aircraft should not be allowed to overshoot or undershoot the cleared flight level by more than 150 ft (45 m);

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

e. An automatic altitude-control system should be operative and engaged during level cruise, except when circumstances such as the need to retrim 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;

f. The altitude-alerting system should be operational;

* g. At intervals of approximately one hour, cross-checks between the primary altimeters and the stand-by altimeter should be made. A minimum of two primary altimeters should agree within 200 ft (60 m) or a lesser value if specified in the aircraft operating manual. (Failure to meet this condition will require that the altimetry system be reported as defective and notified to ATC). The difference between the primary and stand-by altimeters should be noted for use in contingency situations.

(1) The normal pilot scan of cockpit instruments should suffice for altimeter crosschecking on most flights.

(2) At least the initial altimeter cross-check in the vicinity of the point where Class II navigation is begun should be recorded (e.g., on coast out). The readings of the

APPENDIX 4. TRAINING PROGRAMS AND OPERATING PRACTICES AND PROCEDURES

primary and standby altimeters should be recorded and available for use in contingency situations. (Class II navigation is defined in FAA Order 8400.10).

<u>Note.</u> *Future systems may make use of automatic altimeter comparators in lieu of cross-checks* by the crew.

h. Normally, the altimetry system being used to control the aircraft should be selected to provide the input to the altitude-reporting transponder transmitting information to ATC.

i. If the pilot is notified by ATC of an AAD error which exceeds 300 ft (90 m) then the pilot should take action to return to CFL as quickly as possible.

* j. Contingency procedures after entering RVSM airspace. The pilot should notify ATC of contingencies (aircraft system failures, weather conditions) which affect the ability to maintain the CFL and co-ordinate a plan of action. Appendix 5 contains detailed guidance for contingency procedures for oceanic airspace. (Other appendices may be added as necessary to address additional areas of operation.)

6 <u>Post Flight</u>.

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

(1) Primary and standby altimeter readings.

(2) Altitude selector setting.

(3) Subscale setting on altimeter.

(4) Autopilot used to control the airplane and any differences when the alternate system was selected.

(5) Differences in altimeter readings if alternate static ports selected.

(6) Use of air data computer selector for fault diagnosis procedure.

APPENDIX 4. TRAINING PROGRAMS AND OPERATING PRACTICES AND PROCEDURES

(7) Transponder selected to provide altitude information to ATC and any difference if alternate transponder or altitude source is manually selected.

7. Special Emphasis Items: Flightcrew Training. The following items should also be included in flightcrew training programs:

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

b. importance of crew members cross checking each other to ensure that ATC clearances are promptly 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 SSEC/PEC through the use of correction cards;

d. problems of visual perception of other aircraft at 1,000 ft (300 m) planned separation during night conditions, when encountering local phenomena such as northern lights, for opposite and same direction traffic, and during turns;

e. characteristics of aircraft altitude capture systems which may lead to the occurrence of overshoots;

* f. operational procedures and operating characteristics related to TCAS (ACAS) operation in an RVSM operation;

g. relationship between the altimetry, automatic altitude control, and transponder systems in normal and abnormal situations;

h. Aircraft operating restrictions (if required for the specific aircraft group) related to RVSM airworthiness approval. (See paragraph 7c(4)(iii)); and

* i. Use of track offset procedures to mitigate the effect of wake turbulence.

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

1. INTRODUCTION

* a. RVSM was initially implemented in North Atlantic Minimum Navigation Performance Specification (NAT MNPS) airspace in March 1997. The guidance which follows has been applied in the NAT region since that time. It will be applied to RVSM operations in Pacific oceanic airspace and can be adapted to RVSM operations in other oceanic airspaces.

* b. This appendix contains information on procedures which are unique to oceanic RVSM airspace. Contingency procedures contained in regional supplementary procedures and guidance which is specifically related to RVSM are presented in this appendix. Contingencies which relate to lateral as well as vertical navigation are also discussed.

2. GENERAL INFORMATION: AIRSPACE DIMENSIONS

a. NAT MNPS AIRSPACE.

* (1) When RVSM was implemented in NAT MNPS airspace, NAT MNPS approval expanded to encompass demonstration of special qualification for both lateral navigation and height-keeping performance.

* (2) NAT MNPS airspace now has a ceiling of FL 420 and a floor of FL 285. As of October 1998, 1,000 ft (300 m) vertical separation is applied between aircraft operating between FL 310 and FL 390 (inclusive). At a future date, planning calls for RVSM to be expanded to apply in NAT MNPS between FL 290 and FL 410 (inclusive).

* b. PACIFIC OCEANIC AIRSPACE. RVSM is planned to be implemented in the Pacific oceanic Flight Information Regions (FIRs) between FL 290 and FL 390 (inclusive). NOTAMS and State Aeronautical Information Publications (AIPs) should be consulted for current implementation plans and schedules in specific FIRs.

3. INTENDED USE OF THIS MATERIAL.

a. Paragraph 4, Basic Concepts For Contingencies. This paragraph is intended to provide an overview of contingency procedures. It is intended to orient the pilot's thinking to the concepts involved and aid in understanding the specific guidance detailed in paragraph 5 and 6. This material should be included in training programs and appropriate flight crew manuals.

* b. Paragraph 5, Guidance To The Pilot In the Event of Equipment Failures or Encounters With Turbulence After Entering RVSM Airspace. This paragraph details summary guidance on specific actions for the pilot to take to mitigate the potential for

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conflict with other aircraft in the situations listed. It should be reviewed in conjunction with Paragraph 6 which provides additional technical and operational detail. The pilot actions in Paragraph 5 should be considered **required pilot knowledge** and should be included in training/qualification programs and appropriate flight crew manuals.

* c. Paragraph 6, Expanded RVSM Equipment Failure and Turbulence Scenarios. This paragraph reviews the situations discussed in Paragraph 5 in greater detail. The material may be used in training programs as an operator deems appropriate.

* d. Paragraph 7, Contingency Procedures published in ICAO Document 7030, Regional Supplementary Procedures. This paragraph lists the "Special Procedures for In-flight Contingencies" published for various ICAO regions in the Doc 7030. These procedures should be considered **required pilot knowledge.** The material may be condensed for ease of presentation and should be included in training/qualification programs and appropriate flight crew manuals.

* e. Paragraph 8, Wake Turbulence Procedures. Paragraph 8 discusses published procedures for the pilot to follow in the event that wake turbulence is encountered. These procedures should be considered **required pilot knowledge**.

f. Paragraph 9, RVSM Transition Areas. Paragraph 9 highlights the necessity for pilots to be informed on policy and procedures established for operation in RVSM transition areas. This information should be addressed in training programs and manuals.

4. BASIC CONCEPTS FOR CONTINGENCIES.

* a. General. The in-flight contingency procedures for the NAT, published in Doc 7030, were revised to provide for RVSM implementation in NAT MNPS airspace. Specifically, NAT Regional Supplementary Procedures, Paragraph 5.0 was revised to account for RVSM operations. NATSPG developed draft Paragraph 5.0 revisions which were endorsed by the Limited NAT Regional Air Navigation Meeting in November 1992. They were made effective at the start of operational trials in March 1997. (Aircraft were separated vertically above FL 290 by 1,000 ft (300 m) in the NAT for the first time when operational trials were begun). The NAT Operations Manual was also revised with this material prior to the start of operational trials.

b. The basic concepts for contingencies described in this paragraph have been developed from the specific guidance contained in Doc 7030 paragraphs published for individual ICAO regions entitled "Special Procedures for In-flight Contingencies". Contingency procedures become complicated when specific situations are detailed. However, if the details are examined in the context of certain basic concepts, then they are more easily understood. Reviewing these concepts should serve to aid pilots' understanding of the specific contingency procedures detailed in the Doc 7030 paragraphs.

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c. The basic concepts for contingencies are:

(1). Guidance for contingency procedures should not be interpreted in any way which prejudices the final authority and responsibility of the pilot in command for the safe operation of the aircraft.

(2). If the pilot is unsure of the vertical or lateral position of the aircraft or the aircraft deviates from its assigned altitude or track for cause without prior ATC clearance, then the pilot must take action to mitigate the potential for collision with aircraft on adjacent routes or flight levels.

* (i) In this situation, the pilot should alert adjacent aircraft by making maximum use of aircraft lighting and broadcasting position, flight level, and intentions on 121.5 MHz (as a back-up, the appropriate VHF inter-pilot air-to-air frequency may be used);

(3) Unless the nature of the contingency dictates otherwise, the pilot should advise ATC as soon as possible of a contingency situation and if possible, request an ATC clearance before deviating from the assigned route or flight level.

(4) If a revised ATC clearance cannot be obtained in a timely manner and action is required to avoid potential conflict with other aircraft, then the aircraft should be flown at an altitude and/or on a track where other aircraft are <u>least</u> likely to be encountered:

(i) This can be accomplished by offsetting from routes or altitudes normally flown in the airspace. The Doc 7030 paragraphs entitled “Special Procedures for In-flight Contingencies” provide recommendations on the order of preference for the following pilot actions:

(A) The pilot may offset half the lateral distance between routes or tracks.

(B) The pilot may offset half the vertical distance between altitudes normally flown.

(C) The pilot may also consider descending below FL 285 or climbing above FL 410. (The vast majority of oceanic traffic has been found to operate between FL 290 and 410. Flight above FL 410 or below FL 285 may limit exposure to conflict with other aircraft).

(5). When executing a contingency maneuver the pilot should:

(i) Watch for conflicting traffic both visually and by reference to ACAS, if equipped.

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* (ii) Continue to alert other aircraft using 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used) and aircraft lights.

(iii) Continue to fly offset tracks or altitudes until an ATC clearance is obtained.

(iv) Obtain an ATC clearance as soon as possible.

5. GUIDANCE TO THE PILOT (INCLUDING EXPECTED ATC ACTIONS) IN THE EVENT OF EQUIPMENT FAILURES OR ENCOUNTERS WITH TURBULENCE AFTER ENTRY INTO RVSM AIRSPACE. In addition to emergency conditions that require immediate descent, such as loss of thrust or pressurization, ATC should be made aware of the less explicit conditions that may make it impossible for an aircraft to maintain its CFL appropriate to RVSM. Controllers should react to such conditions but these actions cannot be specified, as they will be dynamically affected by the real-time situation.

* a. Objective of the Guidance Material. The following material is provided with the purpose of giving the pilot guidance on actions to take under certain conditions of equipment failure and encounters with turbulence. It also describes the expected ATC controller actions in these situations. It is recognized that the pilot and controller will use judgment to determine the action most appropriate to any given situation. The guidance material recognizes that for certain equipment failures, the safest course of action may be for the aircraft to maintain the assigned FL and route while the pilot and controller take precautionary action to protect separation. For extreme cases of equipment failure, however, the guidance recognizes that the safest course of action may be for the aircraft to depart from the cleared FL or route by obtaining a revised ATC clearance or if unable to obtain prior ATC clearance, executing the established Doc 7030 contingency maneuvers for the area of operation.

Note: Paragraph 6 provides an expanded description of the scenarios detailed below.

* b. CONTINGENCY SCENARIOS. The following paragraphs summarize pilot actions to mitigate the potential for conflict with other aircraft in certain contingency situations. They should be reviewed in conjunction with the expanded contingency scenarios detailed in Paragraph 6 which contain additional technical and operational detail.

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<u>*Scenario 1:</u> The pilot is: 1) unsure of the vertical position of the aircraft due to the loss or degradation of all primary altimetry systems, or 2) unsure of the capability to maintain CFL due to turbulence or loss of all automatic altitude control systems.

The Pilot should:	ATC can be expected to:
Maintain CFL while evaluating the situation;	
Watch for conflicting traffic both visually and by reference to ACAS, if equipped;	
If considered necessary, alert nearby aircraft by 1) making maximum use of exterior lights; 2) broadcasting position, FL, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used).	
Notify ATC of the situation and intended course of action. Possible courses of action include:	Obtain the pilot's intentions and pass essential traffic information.
1) maintaining the CFL and route provided that ATC can provide lateral, longitudinal or conventional vertical separation.	1) If the pilot intends to continue in RVSM airspace, assess traffic situation to determine if the aircraft can be accommodated through the provision of lateral, longitudinal, or conventional vertical separation, and if so, apply the appropriate minimum.
2) requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft cannot maintain CFL and ATC cannot establish adequate separation from other aircraft.	2) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.
3) executing the Doc 7030 contingency maneuver to offset from the assigned track and FL, if ATC clearance cannot be obtained and the aircraft cannot maintain CFL.	3) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, advise the pilot of essential traffic information, notify other aircraft in the vicinity and continue to monitor the situation.
	4) Notify adjoining ATC facilities/sectors of the situation.

<u>*Scenario 2:</u> There is a failure or loss of accuracy of one primary altimetry system (e.g., greater than 200 foot difference between primary altimeters)

The Pilot should
Cross check standby altimeter, confirm the accuracy of a primary altimeter system and notify ATC of the loss of redundancy. If unable to confirm primary altimeter system accuracy, follow pilot actions listed in the preceding scenario.

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*6. EXPANDED EQUIPMENT FAILURE AND TURBULENCE ENCOUNTER SCENARIOS. Operators may consider this material for use in training programs.

***Scenario 1: All automatic altitude control systems fail (e.g., Automatic Altitude Hold).**

The Pilot should	**ATC can be expected to**
Initially	
Maintain CFL	
Evaluate the aircraft's capability to maintain altitude through manual control.	
Subsequently	
Watch for conflicting traffic both visually and by reference to TCAS, if equipped.	
If considered necessary, alert nearby aircraft by 1) making maximum use of exterior lights; 2) broadcasting position, FL, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used.)	
Notify ATC of the failure and intended course of action. Possible courses of action include:	
1) maintaining the CFL and route, provided that the aircraft can maintain level.	1) If the pilot intends to continue in RVSM airspace, assess traffic situation to determine if the aircraft can be accommodated through the provision of lateral, longitudinal, or conventional vertical separation, and if so, apply the appropriate minimum.
2) requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft cannot maintain CFL and ATC cannot establish lateral, longitudinal or conventional vertical separation.	2) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.
3) executing the Doc 7030 contingency maneuver to offset from the assigned track and FL, if ATC clearance cannot be obtained and the aircraft cannot maintain CFL.	3) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, advise the pilot of essential traffic information, notify other aircraft in the vicinity and continue to monitor the situation.
	4) Notify adjoining ATC facilities/ sectors of the situation.

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***Scenario 2: Loss of redundancy in primary altimetry systems**

The Pilot should	**ATC can be expected to**
If the remaining altimetry system is functioning normally, couple that system to the automatic altitude control system, notify ATC of the loss of redundancy and maintain vigilance of altitude keeping.	Acknowledge the situation and continue to monitor progress

***Scenario 3: All primary altimetry systems are considered unreliable or fail**

The Pilot should	**ATC can be expected to**
Maintain CFL by reference to the standby altimeter (if the aircraft is so equipped).	
Alert nearby aircraft by 1) making maximum use of exterior lights; 2) broadcasting position, FL, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used).	
Consider declaring an emergency. Notify ATC of the failure and intended course of action. Possible courses of action include:	Obtain pilot's intentions, and pass essential traffic information.
1) maintaining CFL and route provided that ATC can provide lateral, longitudinal or conventional vertical separation.	1) If the pilot intends to continue in RVSM airspace, assess traffic situation to determine if the aircraft can be accommodated through the provision of lateral, longitudinal, or conventional vertical separation, and if so, apply the appropriate minimum.
2) requesting ATC clearance to climb above or descend below RVSM airspace if ATC cannot establish adequate separation from other aircraft.	2) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.
3) executing the Doc 7030 contingency maneuver to offset from the assigned track and FL, if ATC clearance cannot be obtained.	3) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, advise the pilot of essential traffic information, notify other aircraft in the vicinity and continue to monitor the situation.
	4) Notify adjoining ATC facilities/sectors of the situation.

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***Scenario 4: The primary altimeters diverge by more than 200ft (60m)**

The Pilot should
Attempt to determine the defective system through established trouble-shooting procedures and/or comparing the primary altimeter displace to the standby altimeter (as corrected by the correction cards, if required).
If the defective system can be determined, couple the functioning altimeter system to the altitude keeping device.
If the defective system cannot be determined, follow the guidance in Scenario 3 for failure or unreliable altimeter indications of all primary altimeters.

***Scenario 5: Turbulence (greater than moderate) which the pilot believes will impact the aircraft's capability to maintain flight level.**

The Pilot should	**ATC can be expected to**
Watch for conflicting traffic both visually and by reference to TCAS, if equipped.	
If considered necessary, alert nearby aircraft by: 1) making maximum use of exterior lights; 2) broadcasting position, FL, and intentions on 121.5 MHz (as a back-up, the VHF inter-pilot air-to-air frequency may be used).	
Notify ATC of intended course of action as soon as possible. Possible courses of action include:	
1) maintaining CFL and route provided ATC can provide lateral, longitudinal or conventional vertical separation.	1) Assess traffic situation to determine if the aircraft can be accommodated through the provision of lateral, longitudinal, or conventional vertical separation, and if so, apply the appropriate minimum.
2) requesting flight level change, if necessary.	2) If unable to provide adequate separation, advise the pilot of essential traffic information and request pilot's intentions.
3) executing the Doc 7030 contingency maneuver to offset from the assigned track and FL, if ATC clearance cannot be obtained and the aircraft cannot maintain CFL.	3) Notify other aircraft in the vicinity and monitor the situation
	4) Notify adjoining ATC facilities/ sectors of the situation.

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*7. SPECIAL PROCEDURES FOR IN-FLIGHT CONTINGENCIES PUBLISHED FOR INDIVIDUAL ICAO REGIONS IN DOC 7030.

* a. The Doc 7030 should be considered the source document for specific contingency procedures applicable to individual ICAO regions. Doc 7030 should always be consulted before training material or manuals are developed.

* b. In-flight contingency procedures applicable to Pacific oceanic operations are published in paragraph 4.0 of the Regional Supplementary Procedures for the Pacific and the Middle East/Asia (Mid/Asia).

* c) In-flight contingency procedures applicable to NAT oceanic operations are published in paragraph 5.0 of NAT Regional Supplementary Procedures.

*8. WAKE TURBULENCE PROCEDURES. The ATS authorities developed pilot and ATC procedures for aircraft experiencing wake turbulence. These procedures provide for the contingency use of a 2 NM lateral offset to avoid exposure to wake turbulence. The procedures have been published in State NOTAMS and AIPs and are planned for publication in Regional Supplementary Procedures. These procedures should be incorporated in pilot training programs and manuals.

9. TRANSPONDER FAILURE AND RVSM TRANSITION AREAS. The specific actions that ATC will take in the event of transponder failure in RVSM transition areas will be determined by the provider States. (Transition areas are planned to be established between airspaces where different vertical separation standards are applied).

APPENDIX 6. REVIEW OF ICAO DOCUMENT 9574 HEIGHT-KEEPING PARAMETERS

1. ICAO Doc. 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 assigned flight level, and this is the only factor addressed in the present document.

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

a. the proportion of height keeping errors beyond 300 feet (90 m) in magnitude must be less than 2.0×10^{-3};

b. the proportion of height keeping errors beyond 500 feet (150 m) in magnitude must be less than 3.5×10^{-6};

c. the proportion of height keeping errors beyond 650 feet (200 m) in magnitude must be less than 1.6×10^{-7}; and

d. the proportion of height keeping errors between 950 feet (290 m) and 1,050 feet (320 m) 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, to satisfy the distributional limits in paragraph 2a, and to result in aircraft airworthiness having negligible effect on meeting the requirements in paragraphs 2b, 2c, and 2d. They are applicable statistically to individual groups of nominally identical aircraft operating in the airspace. These characteristics describe the performance which the groups need to be capable of achieving in service, exclusive of human factors errors and extreme environmental influences, if the airspace system TVE requirements 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 ±80 feet (±25 m);

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 245 feet (75 m); and

c. Errors in altitude keeping shall be symmetric about a mean of 0 feet (0 m) and shall have a standard deviation not greater than 43 feet (13 m) and should be such that the

APPENDIX 6. REVIEW OF ICAO DOCUMENT 9574 HEIGHT-KEEPING PARAMETERS

error frequency decreases with increasing error magnitude at a rate which is at least exponential."

4. ICAO Doc. 9574 recognized 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 to be necessary to set system tolerances at levels which recognize 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 recognized 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 requirements are developed to fulfill the following requirements, where the narrower tolerance in paragraph 5b 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 ±80 feet (±25 m);

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 200 feet (60 m);

c. each individual aircraft in the group shall be built to have ASE contained within ±200 feet (±60 m); and

d. an automatic altitude control system shall be required and will be capable of controlling altitude within a tolerance band of ±50 feet (±15 m) about commanded altitude when operated in the altitude hold mode in straight and level flight under nonturbulent, nongust 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 recognize that the limits are based on studies (Doc. 9536, Volume 2) which showed that ASE tends to follow a normal distribution about a characteristic mean value for the aircraft group. The document should, therefore, provide controls which will preclude the possibility that individual aircraft approvals could create clusters operating with a mean significantly beyond 80 ft (25 m) 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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Appendices

APPENDIX B - The Collision Risk Model for the Vertical Dimension

Part 1: Collision risk model on the same ground track at adjacent flight levels

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

The individual parameters that make up the model statement and their definition are as follows:

CRM Parameter	Description
N_{az}	Number of fatal accidents per flight hour due to loss of vertical separation.
S_z	Vertical Separation minimum.
$P_z(S_z)$	Probability that two aircraft nominally separated by the vertical separation minimum S_z are in vertical overlap.
$P_y(0)$	Probability that two aircraft on the same track are in lateral overlap.
λ_x	Average aircraft length.
λ_y	Average aircraft wingspan.
λ_z	Average aircraft height with undercarriage retracted.
$\hat{S}_x$	Length of longitudinal window used to calculate occupancy.
$E_z(same)$	Same direction vertical occupancy.
$E_z(opp)$	Opposite direction vertical occupancy.
$\left\|\overline{\Delta V}\right\|$	Average relative along track speed between aircraft on same direction routes.
$\left\|\overline{V}\right\|$	Average aircraft ground speed.
$\left\|\overline{\dot{y}}\right\|$	Average relative cross track speed for an aircraft pair nominally on the same track.
$\left\|\overline{\dot{z}}\right\|$	Average relative vertical speed of an aircraft pair that have lost all vertical separation

Same and opposite direction passing frequencies, $N_x(same)$ and $N_x(opp)$, are related to the same and opposite direction vertical occupancies through the following relations:

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

and

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

where the parameters are identical to those described in the previous table.

An equivalent opposite direction passing frequency, as used in the Global System Performance

Specification, can be derived from the same and opposite direction passing frequencies using the following relation:

$$N_x(equivalent) = N_x(opp) + N_x(same)\frac{c_1}{c_2}$$

where:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\bar{\dot{y}}|}{|\overline{\Delta V}|} + \frac{\lambda_x}{\lambda_z}\frac{|\bar{\dot{z}}|}{|\overline{\Delta V}|}\right]$$

and

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\bar{\dot{y}}|}{2|\bar{V}|} + \frac{\lambda_x}{\lambda_z}\frac{|\bar{\dot{z}}|}{2|\bar{V}|}\right]$$

Part 2: Collision risk model for the vertical dimension on the same ground track at adjacent flight levels applied to aircraft descending through flight levels without clearance

Two models are used for the determination of collision risk due to levels crossed without clearance. The choice of models depends on the assumed climb/descent rate. Slowly descending aircraft are assumed to maintain the same attitude as in level flight. Rapidly descending aircraft are assumed to have attitude changes that affect the angle at which the transitioning aircraft cross each flight level and hence the possible size of the collision envelope. Model 1 is employed for climb/descent rates less than or equal to 4000ft/min (approximately 40 knots) while Model 2 is used for emergencies such as pressurization failures which can result in descent rates in the region of 4000ft/min to 6000ft/min (approximately 40 to 60 knots).

Model 1: Climb/Descent Rates ≤ 4000ft/ min(≅ 40 knots)

To estimate the risk associated with aircraft descending through a track it is assumed that the lateral path-keeping performance is no worse than that for an aircraft in level flight. For aircraft descending through flight levels at rates that are consistent with model 1, the collision risk model is:

$$\hat{N}_{az} = P_y(0)\frac{2N_{fl}(s)}{T}\frac{\lambda_x\lambda_z}{S_x|\bar{\dot{z}}_1|}\left\{E_z(same)\left[\frac{|\overline{\Delta V}|}{2\lambda_x} + \frac{|\bar{\dot{y}}|}{2\lambda_y} + \frac{|\bar{\dot{z}}_1|}{2\lambda_z}\right] + E_z(opp)\left[\frac{|\bar{V}|}{\lambda_x} + \frac{|\bar{\dot{y}}|}{2\lambda_y} + \frac{|\bar{\dot{z}}_1|}{2\lambda_z}\right]\right\}$$

The caret over the symbol N_{az} indicates additional risk, T is total system flight time, $N_{fl}(s)$ is the number of flight levels crossed without clearance during slow descents and $\dot{z}_1$ is relative vertical speed for aircraft pairs in model 1 during the crossing.

Model 2: Descent Rates between 4000ft/min and 6000ft/min (≅ 40 to 60 knots)

Model 1 takes no account of the angle at which the transitioning aircraft crosses a particular flight level and assumes the collision risk between two aircraft of length λ_x , wingspan λ_y and height λ_z is equivalent to the collision risk between a particle and a rectangular box of dimensions $2\lambda_x \times 2\lambda_y \times 2\lambda_z$. This assumption is valid for slowly descending or climbing aircraft, but not for aircraft in rapid descent, e.g., during pressurization failure. Model 2, therefore, considers the paths of a rapidly descending aircraft and an aircraft in level flight and represents a collision between them as the entry of the descending aircraft's center into a "lozenge" surrounding the aircraft in level flight. The resulting expression for $\hat{N}_{az}$ is:

$$\hat{N}_{az} = \left(\frac{\lambda_x^2\left(1+\frac{\pi}{4}\right)+2\lambda_x\lambda_z}{2T\,\hat{S}_x\,|\bar{\dot{z}}_2|} \right) N_{fl}(r)\, P_y(0) \left\{ E_z(same)\left[\frac{|\bar{\dot{y}}|}{2\lambda_y} + \frac{\sqrt{(\Delta V)^2+\dot{z}_2^{\,2}}}{\lambda_{xz}(same)}\right] + E_z(opp)\left[\frac{|\bar{\dot{y}}|}{2\lambda_y}+\frac{\sqrt{(2V)^2+\dot{z}_2^{\,2}}}{\lambda_{xz}(opp)}\right]\right\}$$

The above expression contains two new parameters λ_{xz} *(same)* and λ_{xz} *(opp)*. λ_{xz} *(same)* is the average length of the path followed by the descending aircraft's center as it traverses the "lozenge", when the aircraft are headed in the same direction. λ_{xz} *(opp)* is the average path length when the aircraft are headed in opposite directions. The values of these parameters need to be based on ~~PAC~~Asia Pacific aircraft size. For example, using a maximum assumed absolute relative longitudinal speed of 50 knots for aircraft in the NAT, values of λ_{xz} *(same)* and λ_{xz} *(opp)* have been calculated as 0.36143 and 0.0612 respectively. $N_{fl}(r)$ is the number of flight levels crossed without clearance during rapid descents and the symbol $\dot{z}_2$ is the relative vertical speed for aircraft pairs in model 2 during the crossing.

Part 3: Collision risk model for the vertical dimension on the same ground track at adjacent flight levels applied to aircraft adhering to incorrect flight levels

The proportion of the total flying time spent at incorrect levels, Q, is determined by summing the individual times for each large height deviation occurring at an integer multiple, n, of a full separation minimum and dividing by, T, the total system flight time. Q may be interpreted as the probability that an aircraft is flying at an incorrect level. To estimate the probability of vertical overlap during these events, Q is multiplied by the probability, $P_z(0)$, that two aircraft nominally flying at the same level are in vertical overlap. Therefore, the vertical overlap probability arising from deviations that are integer multiples of the vertical separation minimum is given by:

$$\sum_n P_z(nS_z) = P_z(0)Q$$

Having determined $\sum_n P_z(nS_z)$, the collision risk is determined by using the Reich Collision Risk Model presented in part 1 of this appendix.

Part 4: Collision risk model for the vertical dimension for intersecting routes at adjacent flight levels

The mathematical form of the collision risk model for intersecting routes at adjacent flight levels would be extremely complex if aircraft were assumed to have a rectangular shape as in part 1 of this appendix. To reduce this complexity aircraft shapes are assumed to be right circular cylinders. If a given route is crossed by another, the given route's rate of accidents with aircraft on the crossing route, expressed in accidents per flight hour is:

$$\hat{N}_{az} = \frac{2\,P_z(S_z)}{kF}\sum_{j=1}^{N} n_j\, P_o(s_j)\left[1+\frac{|\bar{\dot{z}}|}{2\lambda_z}\,\overline{d_o(s_j)}\right]$$

The new parameters in the above model for intersection routes are as follows:

k = the number of hours during which the intersection's traffic is monitored;

F = the given route's traffic flow expressed in flight-hours per hour;

$P_o(t)$ = the probability that two aircraft experience a horizontal overlap, given that: (1) one of the aircraft is assigned to the given route and the other to the intersecting route; (2) their assigned flight levels differ by S_z; (3) they have t hours difference between their estimated times of arrival at the intersection;

$\overline{d_o(t)}$ = the average duration of a horizontal overlap, given that: (1) one of the aircraft is assigned to the given route and the other to the intersecting route; (2) their assigned flight levels differ by S_z; (3) they have t hours difference between their estimated times of arrival at the intersection; and (4) they experience a horizontal overlap; with each other;

N = an integer chosen to be large enough so that $P_o(t)$ changes by no more than a (small) chosen percentage over each of the intervals

$$\left[\frac{(j-1)t_M}{N}, \frac{jt_M}{N}\right) \text{ for } j = 1,2, \ldots, N;$$

$$s_j = \frac{(2j-1)t_M}{2N} = \text{ the midpoint of the interval } \left[\frac{(j-1)t_M}{N}, \frac{jt_M}{N}\right]$$

n_j = (for j = 1,2,…; N) the number of pairs of aircraft that arrive in the vicinity of the intersection, during k hours of monitoring, with one aircraft assigned to each of the intersecting routes, with the aircraft assigned to flight levels separated by S_z, and with t, the difference between their estimated times of arrival at the intersection, in the interval

$$\left[\frac{(j-1)t_M}{N}, \frac{jt_M}{N}\right]$$

Part 5: Collision risk model for the vertical dimension applied to formation flights

The collision risk model for aircraft in a formation that are paired with typical aircraft at adjacent altitudes is again a modified form of the collision risk model for the vertical dimension as presented in part 1 of this appendix. When aircraft within a formation are paired with typical aircraft at adjacent altitudes the parameter values $2\lambda_x, 2\lambda_y, 2\lambda_z, P_y(0)$ and $P_z(S_z)$ used in part 1 for typical ~~PAC~~Asia Pacific aircraft pairs require modification due to the increased volume of airspace restricted to aircraft within the formation.

Let the shape of formation be represented by a box of length, width and height Γ_x, Γ_y, and Γ_z, respectively. The modified parameters are given in the second column of the following table:

CRM Parameters for Typical Aircraft Pairs	Modified CRM Parameters for Aircraft in Formation Flight paired with Typical Aircraft
$2\lambda_x$	$2\lambda_x + \Gamma_x$
$2\lambda_y$	$2\lambda_y + \Gamma_y$

CRM Parameters for Typical Aircraft Pairs	Modified CRM Parameters for Aircraft in Formation Flight paired with Typical Aircraft
$2\lambda_z$	$2\lambda_{z} + \Gamma_z$
$P_y(0) = \int_{-\lambda_y}^{\lambda_y} \int_{-\infty}^{\infty} h(y)h(y+w)dydw$	$P_y(0) = \int_{-(\lambda_y+\Gamma_y)}^{(\lambda_y+\Gamma_y)} \int_{-\infty}^{\infty} h(y)h(y+w)dydw$
$P_z(S_z) = \int_{S_z-\lambda_z}^{S_z+\lambda_z} \int_{-\infty}^{\infty} f(z)f(z+w)dzdw$	$P_z(S_z) = \int_{S_z-\lambda_z-\Gamma_z}^{S_z+\lambda_z+\Gamma_z} \int_{-\infty}^{\infty} f(z)g(z+w)dzdw$

Comparison of CRM Parameters for Typical Aircraft Pairs and Aircraft in Formation Flight Paired with Typical Aircraft

In the above table *h(y)* is the density function for lateral error, *f(z)* is the TVE density function for approved aircraft and *g(z)* is the TVE density function for aircraft within the formation.

Part 6: Collision risk model for the vertical dimension applied to aircraft in vertical alignment for the entire crossing at adjacent flight levels

Assume there are *n* route categories in a route system and that the average flight time for each category is $T_1, T_2, ..., T_n$. Let the number of flights during which two aircraft are in continual longitudinal overlap be $k_1, k_2, ..., k_n$. Then the additional risk on the entire route system can be expressed by the following equation:

$$\hat{N}_{az} = \frac{2}{T} P_y(0) P_z(S_z) \left[\frac{|\overline{\dot{y}}|}{2\lambda_y} + \frac{|\overline{\dot{z}}|}{2\lambda_z} \right] \sum_{r=1}^{n} k_r T_r$$

Part 7: Summary

The risk estimate in the vertical dimension is estimated as the sum of the risks in each of the six parts of this appendix. It is compared to the regional Pacific Target Level of Safety (TLS) of 5 fatal accidents in 10^9 flying hours which embodies the risk due to the loss of vertical separation from <u>all</u> causes.

APPENDIX C - NAT Simulation Model Description

General

The North Atlantic Traffic Allocation Model (NATTAM) is capable of considering the routes, flight levels, and times of flights in a given schedule against the specified airspace structures and separation minima, either as presently established or as changed to test the effects of proposed changes. Traffic volumes and patterns, the structure of MNPS airspace, the Organized Track System, the availability of given flight levels during given time periods, and the vertical, lateral and longitudinal separation standards can all be varied by the model operator to test the effects of proposed changes on route and flight level allocations. Occupancies may then be calculated from the outputs of the NATTAM program.

The model is able to use an existing Gander OACC daily traffic database (GAATS) summary as the initial list of aircraft, routes, flight levels, times, and speeds. The information on each of the flights listed in the GAATS database is treated as the flight plan considered by the allocation model.

The model considers routes between 50W and 20W, inclusive. If a flight is at all four waypoints (at 50W, 40W, 30W and 20W) corresponding to one of the OTS published tracks and at one of the flight levels for that track during the track times, it is considered as being on that track and is given that track designation. If an aircraft does not meet all these criteria, it is considered "Random"

Re-allocation of flights to 100ft VSM Environment

To determine the effects of 1000 ft VSM on occupancy, 50% of traffic in the base case is re-assigned to even flight levels. In re-assigning traffic to even flight levels, 75% of those eastbound flights which were moved went up 1000 ft, and 25% went down 1000 ft; for those westbound flights which were moved, 25% were put up 1000 ft and 75% were put down 1000 ft. This was done based on the generally accepted understanding that eastbound aircraft are further into their flights and therefore more able to climb.

Concentration of Traffic Towards Core Tracks

With the addition of more available flight levels on the core routes, the traffic is expected to concentrate laterally towards the center of the Track system. The rules which concentrate traffic towards the core track, after the re-allocation of 50% of flights to even flight levels in an 1000 ft environment are:

1. Determine the waypoint co-ordinates of the most used OTS track (the central track).

2. For OTS Flights

2.1 Move 50% of OTS flights which are one track north or south of the most used track, to the center track.

2.2 For OTS flights which are more than one track north or south of the central track, move:

2.2.1 25% two tracks toward the centre,
2.2.2 25% one track towards the centre, and
2.2.3 leave the remaining 50% where they are.

3 For Random Flights

3.1 For flights four or more degreed of latitude from the central track at the start (50^{o} W for eastbound flights and 20^{o} W for westbound flights), leave as is.

3.2 For flights three degrees from the central track at the start of their crossings, move 25% of flights one degree of latitude north or south to a route parallel to its original route so that the start point is closer to the central track.

3.3 For flights one or two degrees from the central track at the start, move 50% of flights to a parallel route one degree of latitude north or south so that the start point is closer to the central track.

Traffic Increases

Traffic increases may be made either by editing existing or adding new flights, or more simply by duplicating a specified percentage of existing flights. Traffic increases are seen to be more heavily concentrated in the peak periods, making the demand peaks even more pronounced. For a selected daily traffic increase percentage, therefore, the shoulder periods are increased at the specified rate. The rate of increase during the peak is a calculated value which will give the specified overall daily percentage increase in the number of flights.

Conflict Resolution

Separation standards will be violated and conflicts generated when the airspace structure is changed, when traffic is reallocated to new routes or flight levels, or when increased traffic levels are introduced. In these cases, as the traffic allocation model moves through the day, when it reaches the time a flight enters the airspace (at 50^{O} W for eastbound and 20^{O}W for westbound flights), it will check against previously cleared flights to determine if a separation standard would be violated. If the requested routing and times cannot be granted without imposing on the separations required with other flights, a series of sequential choices if followed until a conflict-free route at all waypoints is found. Often, flights which are re-cleared affect subsequent flights, resulting in a chain reaction and a significant number of additional re-clearances during busy traffic periods.

The re-clearance sequence used for westbound traffic was obtained from the tables of the resolution algorithms used in the UK Flight Data Processing System, as provided by Shanwick Oceanic Area Control Centre.

Estimation of Vertical Occupancies and Passing Frequencies

Having obtained the revised traffic patterns for the RVSM environment from the simulation model, the program to calculate vertical occupancies and passing frequencies is run in the normal way and these values are used in the Collision Risk Model.

APPENDIX D - Assessment for Compliance with the MASPS

1. The assessment of ASE to confirm compliance with the MASPS requires five basic evaluations – two for individual aircraft, two for aircraft groups, and one for the number of individual aircraft ASE samples. All ASE performance assessments described within this section will be made on MASPS approved aircraft. Specifically, it is necessary to determine that:

   a) an individual aircraft's sample ASE mean indicates that the true ASE mean for the airframe meets airworthiness requirements;

   b) the ASE mean and standard deviation from operators of similar aircraft groups are consistent;

   c) an aircraft group's sample ASE mean and standard deviation indicate that the aircraft group's true ASE mean and standard deviation meet airworthiness requirements;

   d) the ASE mean for individual aircraft is stable over time; and

   e) the number of samples from an aircraft group needed to assure that the remaining non-sampled aircraft in the group, by themselves would not cause the system to exceed the TLS.

2. To confirm that the ASE of an individual aircraft is within an acceptable range of values and meets the airworthiness requirements necessitates a statistical evaluation. It is designed to aid in making decisions under the uncertainty created by normal performance variation and measurement errors. In RVSM, the maximum acceptable magnitude for the mean ASE of individual aircraft, which is from an aircraft group that meets the MASPS group requirement, is 245 ft. Two critical values (target levels) were established and are compared to the measured ASE. One target level is set at 300 ft and is larger than the maximum acceptable ASE mean. It guards against a compliant aircraft being scrutinized for deficiencies due to the uncertainty of measurement error. If individual aircraft measured ASE is above this target level, ASE performance is judged to be non-compliant. If individual aircraft ASE is below this target value, ASE performance is judged to be in compliance. However, this leaves a possibility that a marginally non-compliant aircraft is judged to be compliant. Therefore, a second target level is set (160 ft) and is smaller than the maximum acceptable ASE mean. It guards against a marginally non-compliant aircraft being accepted as compliant. If individual aircraft measured ASE is above this target level and below the first target level, ASE; performance is judged to be aberrant. If individual aircraft ASE is below this target value, ASE performance is judged to be normal.

3. Unfortunately, even with the above precautions, the possibility of incorrect decisions cannot be eliminated since only a sample (and not the true value) of an individual aircraft's ASE is available from the monitoring program.

4. The assessment of ASE for an individual operator of an aircraft group (usually aircraft of the same type or series with similar altimetry systems) will be made by comparing the ASE performance of the individual operator being assessed to other individual operators of the same aircraft group which have exhibited consistent ASE performance.

5. The assessment of ASE for an aircraft group begins by creating a chart of sample aircraft group means and standard deviations against a template defining the permissible region of airworthiness requirements. The purpose of the assessment is to confirm that the aircraft's true ASE

mean and standard deviation meet the MASPS airworthiness requirements for an aircraft group. The testing concept is similar to the assessment of individual aircraft, however, due to the simultaneous testing of both the ASE mean and standard deviation, the test is inherently more complex. Instead of comparing the measured values to a target level, it is necessary to simultaneously compare them to a two-dimensional region.

6. In addition, underlying the development of the MASPS is the assumption that the distribution of ASE for each aircraft type follows a Gaussian distribution. It is critical to confirm this assumption in order to use the chart show in Figure 1 and be assured that the resulting risk due to ASE is negligible.

7. ASE for an individual aircraft is considered to be stable if the statistical distribution of ASE is the same for all times t. That is, the distribution of ASE for an individual aircraft at some initiating time, t_0, is the same as the distribution of ASE at some later final time, t_f. Since it is assumed that individual aircraft ASE can be described by a Gaussian distribution, which is completely characterized by a mean and variance, the stability of ASE for an individual aircraft can be evaluated by comparing estimates of ASE means and standard deviations at different and widely spaced times, t_0 and t_f. It is assumed that the ASE mean values of several individual aircraft will be measured repeatedly during the Verification and Trial Phases of the monitoring effort.

8. The monitoring targets for the Verification Phase have been designed to provide a monitoring sample that is representative of all the different aircraft types, operators and altimetry system fits. A single aircraft with a large non-compliant ASE can break the system TLS within a very short period of time. Any sampling procedure that does not require a complete census of ~~PAC~~Asia Pacific airframes permits a finite possibility that a non-compliant aircraft will remain undetected. However during the first RVSM implementation, it was felt by the NAT SPG that to perform a complete census during the Verification Phase was neither a realistic nor a practical goal. Nevertheless, the ultimate objective is still a complete census. It is to be achieved as soon as possible into the RVSM trial and prior to the RVSM Operational Phase.

9. Assessment of FTE for compliance with MASPS

9.1 FTE is gathered through pilot and ATC reports of large height deviations and Mode C data. These data are compared to an exponentially decreasing function that describes the maximum acceptable frequency of FTE of different magnitudes. If the measured FTEs are below the functional values, aircraft performance is considered to be compliant.

APPENDIX E - JAA Temporary Guidance Leaflet – 6

LEAFLET NO 6: 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).

LIST OF CONTENTS

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. 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;

- introduction of a new material applicable to the European RVSM airspace in Appendix 6.

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.

Since these revisions do not alter the basic technical criteria, previously established for RVSM approvals, revision marks have been omitted from this 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.

1. PURPOSE

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 9572, RGCSP, Seventh Meeting, Montreal 30 October - 20 November 1990.

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

ICAO Document 7030, Regional Supplementary Procedures- European Region.

EUROCONTROL Manual on Operational ATC Aspects in European RVSM airspace .

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).

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 :

(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.

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.

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

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

Static Source Error Correction (SSEC) A correction 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

Abbreviation	Meaning
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

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.

7.3.2 Assessment of ASE, whether based on measured or predicted data will need to consider sub-paragraphs (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 type certification 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 sub-paragraph 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 certification was made prior to January 1, 1997, need not be replaced or modified.

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 7.3.7, 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 7.3.7, 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 7.3.7 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 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 7.3.7, 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 7.3.7, 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.

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 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.

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.

These items 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.

TABLE 1 - FULL RVSM ENVELOPE BOUNDARIES

	Lower Boundary is defined by	**Upper Boundary is defined by**
Level	• FL 290	The lower of : • FL 410 • Aircraft maximum certified altitude • Altitude limited by: cruise thrust; buffet; other aircraft flight limitations
Mach or Speed	The lower of : • Maximum endurance (holding speed) • Manoeuvre speed	The lower of : • M_{MO}/V_{MO} • Speed limited by cruise thrust; buffet; other aircraft flight limitations
Gross Weight	• The lowest gross weight compatible with operations in RVSM airspace	• 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 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 ±60m (±200 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 ±60m (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 ±60m (±200 ft) then it should receive corrective action.

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 7.3.7 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 7.3.7 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.

(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 referred to 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/MEL.

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.

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 carried out as required 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;
(c) where necessary, operating procedures unique to the airspace have been incorporated in operations manuals (see Appendices 6 and 7);
(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.

(b) *Description of Aircraft Equipment* A description of the aircraft equipment 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. Appendix 6 presents procedures used within airspace of the EUR region as defined in Doc 7030. Appendix 7 presents procedures that are unique to North Atlantic airspace for which specific State operational approval is required as stated in Doc 7030.

(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.

<u>11.4 Demonstration Flight(s)</u>

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.

<u>11.5 Form of Approval Documents</u>

(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 legislation where State 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.

<u>11.6 Airspace Verification/Monitoring Programmes</u>

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 RVSM approval.

<u>11.7 Suspension or Revocation of RVSM Approval</u>

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 operator response to a height keeping error is not effective or timely. The responsible authority will consider the operator's past performance record in determining the action to be taken. If an operator shows a history of operational and/or airworthiness errors, then approval may be suspended until the root causes of these errors are shown to have been eliminated and that the operator's RVSM programmes and procedures are effective.

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.

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

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.

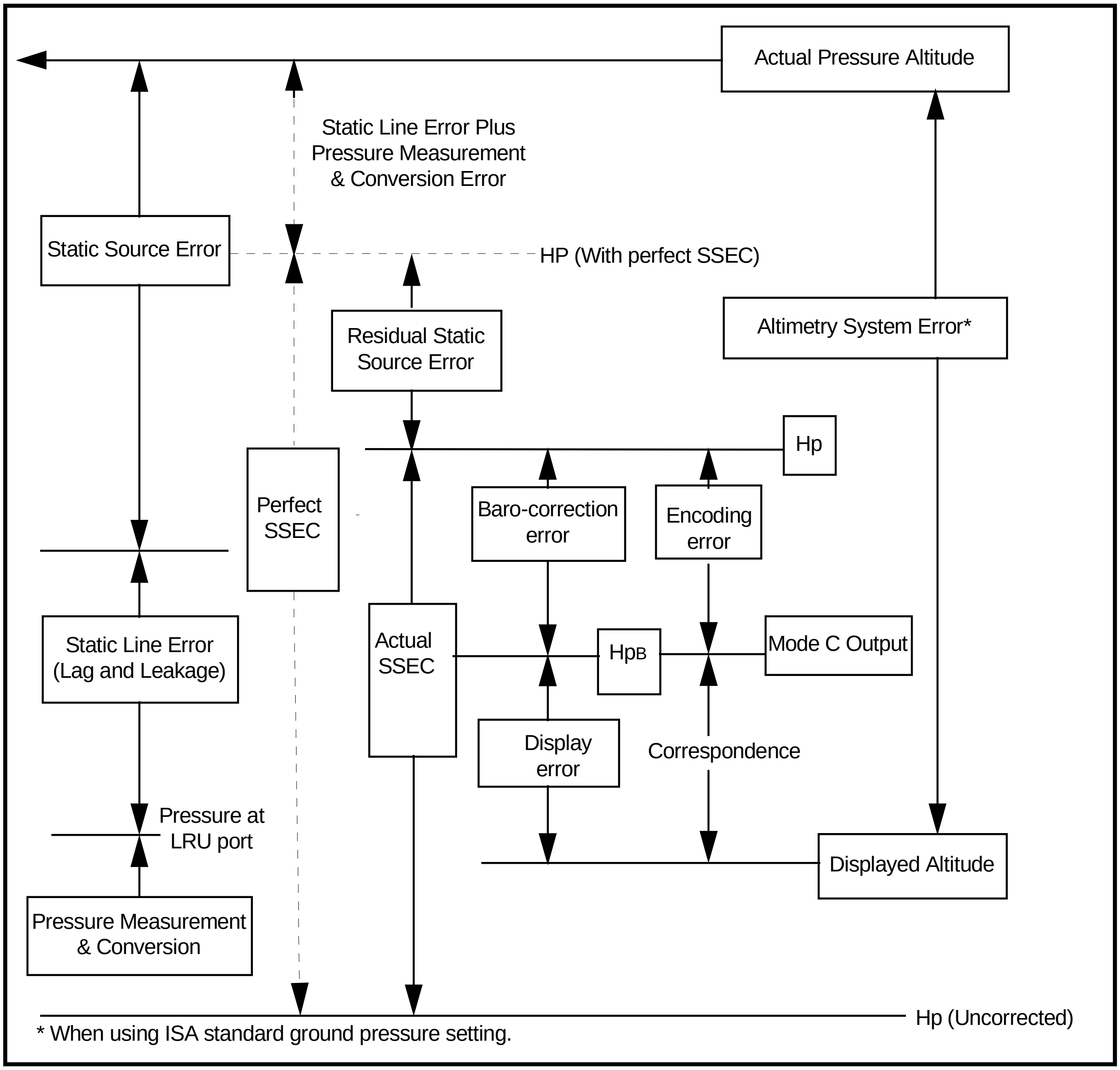
(b) 'Static Source Error' is the difference between the undisturbed ambient pressure and the pressure within the static port, at the input end of the static pressure line.

(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 (Hp) 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 Hp 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.

FIGURE 2-1 ALTIMETRY SYSTEM ERRORS



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(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-l 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.

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.

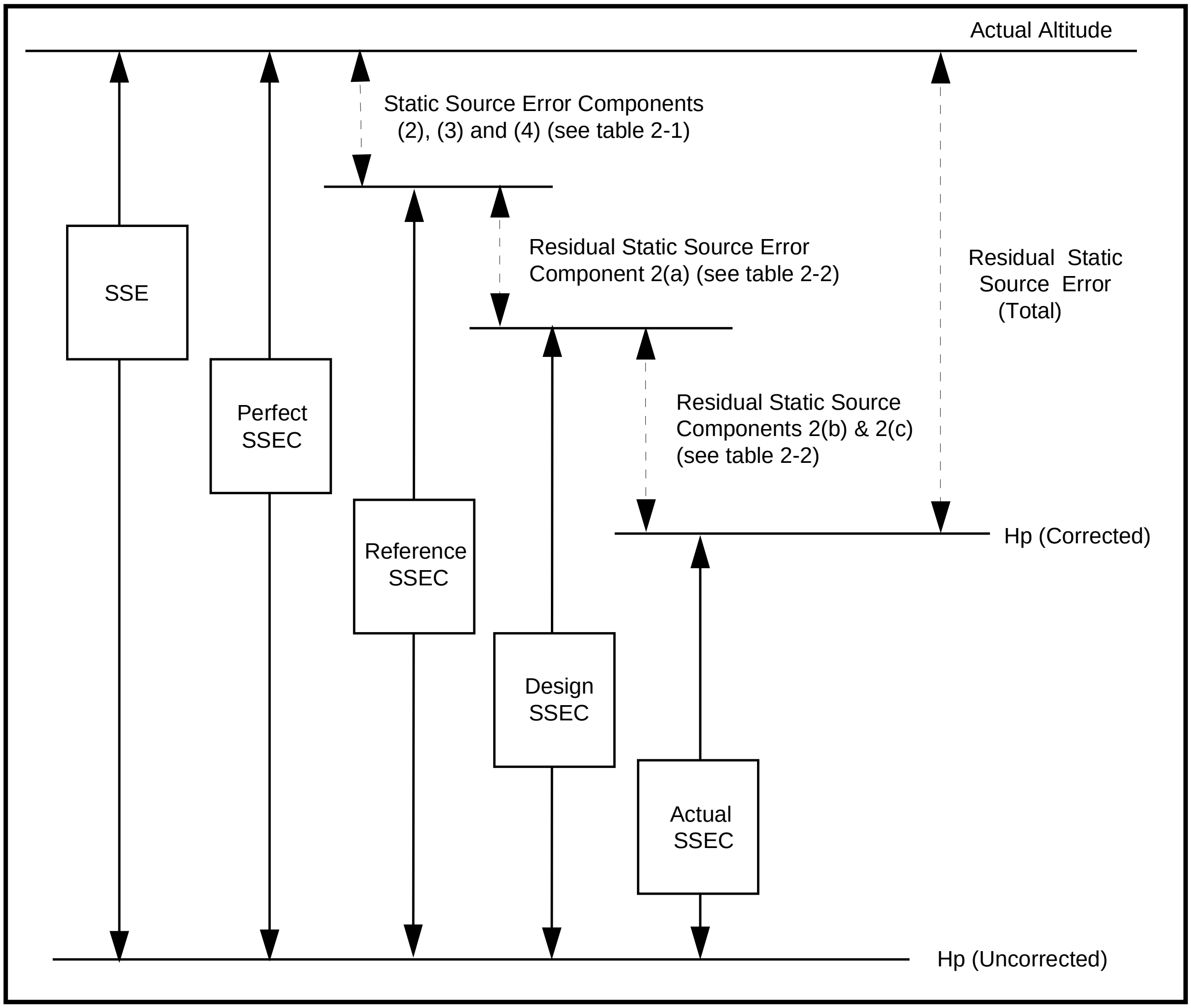
TABLE 2-1 STATIC SOURCE ERROR
(Cause: Aerodynamic Disturbance to Free-Stream Conditions)

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. 3) Airframe to airframe variability. 4) Probe/port to probe/port variability.
Probe/Port Effects Operating Condition (Speed, altitude, angle of attack, sideslip) Geometry: Shape of probe/port; Manufacturing variations; Installation variations.	

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.

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.

(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.

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.

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