MATERIAL DE ORIENTACION

SOBRE

LA IMPLANTACION DE UNA SEPARACION VERTICAL MÍNIMA DE 300 M (1000 FT) ENTRE FL290 y FL410 INCLUSIVE PARA SU APLICACION EN EL ESPACIO AEREO DE LAS REGIONES DEL CARIBE Y SUDAMERICA

BORRADOR
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El *Manual de orientación sobre la implantación de una separación vertical mínima de 300 m (1000ft) entre FL 290 y FL 410 inclusive para su aplicación en el espacio aéreo de las Regiones del Caribe y Sudamérica* es publicado por el Subgrupo ATM/CNS del Grupo Regional de Planificación y Ejecución del Caribe/Sudamérica (GREPECAS), y describe los conceptos, procedimientos para la aprobación operacional y de aeronavegabilidad, análisis de seguridad y los procesos a tener en cuenta en la implantación RVSM en las Regiones CAR/SAM*.

**Nota: Para fines de este documento, las Regiones del Caribe y Sudamérica serán consideradas como una sola región, es decir, la Región CAR/SAM.*

El GREPECAS y sus órganos auxiliares publicarán las versiones revisadas del Documento que fueran necesarias para reflejar las actividades de implantación vigentes.

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OFICINA NACC DE LA OACI

CIUDAD DE MEXICO, MEXICO

e-mail	:	icaonacc@mexico.icao.int
Web site	:	www.icao.int/nacc
Fax	:	+5255 5203-2757
Correo	:	Apartado Postal 5377, México 5 D.F., México
e-mail del PCO	:	TBD

OFICINA SAM DE LA OACI

LIMA, PERU

e-mail	:	mail@lima.icao.int
Web site	:	www.lima.icao.int
Fax	:	+511 575-0974 / 575-1479
Correo	:	Apartado Postal 4127, Lima 100, Perú
e-mail del PCO	:	jf@lima.icao.int / jm@lima.icao.int

La presente edición incorpora todas aquellas revisiones y modificaciones surgidas hasta Octubre de 2003. Las enmiendas y/o corrigendos posteriores se indicarán en la Tabla de Registro de Enmiendas y Corrigendos, conforme al procedimiento establecido en la página iii.

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REGISTRO DE ENMIENDAS Y CORRIGENDOS

ENMIENDAS			
Núm.	Fecha de aplicación	Fecha de anotación	Anotada por

CORRIGENDOS			
Núm.	Fecha de aplicación	Fecha de anotación	Anotada por

ENMIENDAS AL MANUAL DE ORIENTACIÓN SOBRE LA IMPLANTACIÓN DE UNA SEPARACIÓN VERTICAL MÍNIMA DE 300 M (1000 FT) ENTRE FL 290 Y FL 410 INCLUISVE PARA SU PALICACIÓN EN EL ESPACIO AÉREO DE LAS REGIONES DEL CARIBE Y SUDAMÉRICA

1. El *Manual de orientación sobre la implantación de una separación vertical mínima de 300 m (1000ft) entre FL 290 y FL 410 inclusive para su aplicación en el espacio aéreo de las Regiones del Caribe y Sudamérica*, es un documento regional que incorpora los avances científicos y tecnológicos aeronáuticos; así como las experiencias operacionales, tanto de las propias Regiones CAR/SAM como de las otras regiones de la OACI, que pudieran afectar a los conceptos, procedimientos y procesos para la implantación RVSM establecidos en el mismo.

2. Debido a esta particularidad, este Manual de Orientación para la Implantación RVSM es también un documento dinámico, en continuo progreso y permeable para aceptar todas aquellas modificaciones originadas por el constante avance de las disciplinas y actividades aeronáuticas que permitan su utilización para una implantación armonizada de la RVSM en las Regiones CAR/SAM.

3. Para poder mantener al día y realizar los cambios y/o modificaciones que este Manual de Orientación para la Implantación RVSM requiera, se han establecido los procedimientos de enmienda que siguen a continuación.

4. El Manual de Orientación para la Implantación RVSM consta de una serie de hojas sueltas organizadas en secciones y partes que describen los conceptos, procedimientos y procesos aplicables para la implantación RVSM en las regiones CAR/SAM.

5. La estructura de las secciones y partes, así como la numeración de las páginas se han formulado de modo que sea flexible y fácil de revisar o añadir nuevos textos. Cada sección es independiente e incluye una introducción donde se plantea su finalidad y vigencia.

6. Las páginas contienen la fecha de publicación, cuando se considera necesario. Las páginas de reemplazo se publican cuando sea necesario y toda porción de la página que ha sido revisada se señala con una línea vertical en el margen. A medida que se necesite se incorporarán textos adicionales en las secciones existentes o serán tema de nuevas secciones.

7. Los cambios se señalan con una línea vertical en el margen del modo siguiente:

Cursivas	*para texto nuevo o revisado;*
Cursivas	*para una modificación de carácter editorial que no altera ni el fondo ni el sentido del texto;*
Tachado	para el texto que ha sido suprimido.

8. La ausencia de barras de cambio cuando se hayan cambiado los datos o los números de las páginas, significará que se vuelve a publicar la sección en cuestión o que el texto se ha reorganizado (por ejemplo después de una inserción o supresión sin ningún otro cambio).

Prefacio

Este documento tiene como propósito brindar orientación a los explotadores y proveedores de servicio en preparación para la implantación de la RVSM en las Regiones del Caribe y Sudamérica. El documento toma en cuenta el resultado de años de estudio y análisis a nivel internacional, y refleja tanto las normas internacionales de seguridad operacional desarrolladas por el Grupo de Expertos sobre la Revisión del Concepto General de Separación (RGCSP) como la experiencia acumulada a través de otras implantaciones regionales. El Doc 9574 de la OACI, *Manual de Implantación de una Separación Vertical Mínima de 300 m (1 000 ft) entre FL 290 y FL 410 Inclusive;* y el Doc 002 de la Región del Atlántico Norte (NAT), *Material de Orientación sobre la Implantación de una Separación Vertical Mínima de 300 m (1000 ft) en el Espacio Aéreo de la Región del Atlántico Norte donde se aplica las Especificaciones de Performance Mínima de Navegación*; y el *Material de Orientación sobre la Implantación de una Separación Vertical Mínima de 300 m (1000 ft) entre FL290 y FL410 Inclusive para su Aplicación en el Espacio Aéreo de la Región Asia Pacífico,* sirvieron de material para este documento.

Este documento fue desarrollado por autoridades ATS, expertos en aeronavegabilidad y usuarios del espacio aéreo, dentro del contexto del Grupo de Tarea RVSM del Grupo Regional CAR/SAM de Planificación y Ejecución (GREPECAS). Contiene una breve historia del desarrollo de los materiales de orientación de la OACI; y brinda orientación sobre la aprobación de aeronaves y explotadores, los requisitos y procedimientos para los servicios de tránsito aéreo y las tripulaciones de vuelo, y la vigilancia del espacio aéreo RVSM.

Se espera que la publicación de este material de orientación contribuya a lograr un estado de preparación para la implantación de la RVSM, brindando la información que necesitan los usuarios del espacio aéreo para obtener las aprobaciones, y las autoridades ATS para hacer los cambios oportunos y apropiados en cuanto a los procedimientos y la automatización.

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LISTA DE ACRÓNIMOS

AAD	desviación respecto a la altitud asignada
AKD	dispositivo de mantenimiento de altitud
APANPIRG	Grupo Regional Asia/Pacífico de Planificación y Ejecución de la Navegación Aérea
APARMO	Organización de Registro y Vigilancia de Aprobaciones de la Región Asia/Pacífico
ASE	error del sistema altimétrico
ATC	control de tránsito aéreo
ATS	servicios de tránsito aéreo
CAR	Caribe
CFL	nivel de vuelo autorizado
CMA	agencia central de monitoreo
CRM	modelo de riesgo de colisión
FL	nivel de vuelo
FTE	error técnico de vuelo
GMS	sistema de vigilancia basado en el sistema mundial de determinación de la posición
GMU	monitor del sistema mundial de determinación de la posición
GNE	error grave de navegación
GPS	sistema mundial de determinación de la posición
GREPECAS	Grupo Regional CAR/SAM de Planificación y Ejecución
HMU	monitor de altitud
ICAO	Organización de Aviación Civil Internacional
in. Hg	pulgadas de mercurio
JAA	Autoridades Conjuntas de Aviación
MASPS	especificación de performance mínima de los sistemas de aeronave
NAT	Atlántico septentrional
NAT SPG	Grupo sobre Planeamiento de Sistemas Atlántico septentrional
OTS	sistema organizado de derrotas
PAC	Pacífico
PEC	corrección de error de posición
P_y (0)	probabilidad de superposición lateral para aeronaves que vuelan en la misma ruta (es decir, sin una planificación de distancia lateral entre aeronaves que vuelan en la misma ruta)
P_z (1000)	probabilidad de superposición vertical para aeronaves con una separación planificada de 1000 ft entre niveles de vuelo
RGCSP	Grupo de Expertos sobre el Examen del Concepto General de Separación
RPG	grupo regional de planificación
RVSM	separación vertical mínima reducida de 300m (1000 ft) entre niveles de vuelo
SAM	Sudamérica
SD	desviación característica
SDB	base de datos nacional
SSEC	corrección de error de la fuente de presión estática
SSR	radar secundario de vigilancia
TLS	nivel deseado de seguridad
TVE	error vertical total
VSM	separación vertical mínima

LISTA DE DEFINICIONES

Las siguientes definiciones tienen como finalidad aclarar ciertos términos especializados utilizados en este manual.

Grupos de tipos de aeronaves.
Se considera que unas aeronaves pertenecen al mismo grupo si han sido diseñadas y construidas por el mismo fabricante y si su diseño y construcción son nominalmente idénticos respecto a todos los detalles que podrían tener repercusiones en la performance de mantenimiento de altitud.

Error del sistema altimétrico (ASE).
Diferencia entre la altitud indicada por el altímetro, en el supuesto de un reglaje barométrrico correcto, y la altitud de presión correspondiente a la presión ambiente sin perturbaciones.

Distribución de errores del sistema altimétrico.
La distribución de un conjunto de errores del sistema altimétrico.

Desviación respecto a la altitud asignada (AAD).
Diferencia entre la altitud obtenida del transpondedor en Modo C y la altitud o nivel de vuelo asignados.

Dispositivo automático de mantenimiento de altitud.
Todo equipo cuyo diseño permite el control automático de la aeronave respecto a una altitud de presión de referencia.

Riesgo de colisión.
Número anticipado de accidentes de aeronaves en vuelo en un volumen determinado de espacio aéreo, correspondiente a un número específico de horas de vuelo. (Nota – se considera que una colisión ocasiona dos accidentes).

Frecuencia de cruce de derrotas.
Frecuencia de casos en que dos aeronaves se hallan dentro de una determinada distancia al viajar en rutas convergentes en niveles de vuelo adyacentes y con la separación vertical planificada.

Frecuencia equivalente de encuentro en sentidos opuestos.
Valor único calculado en base a una combinación de frecuencias de encuentros en el mismo sentido y en sentidos opuestos que hacen el mismo aporte a la evaluación del riesgo de colisión. Permite una fácil comparación de distintos conjuntos de frecuencias de encuentros en el mismo sentido y en sentidos opuestos.

Error técnico de vuelo (FTE).
Diferencia entre la altitud indicada por el altímetro utilizado para controlar la aeronave y la altitud o nivel de vuelo asignados.

Capacidad de mantenimiento de altitud.
Performance de mantenimiento de altitud de la aeronave que puede esperarse bajo condiciones ambientales nominales de operación, aplicando métodos de operación y mantenimiento de aeronaves apropiados.

Performance de mantenimiento de altitud.
Performance observada de la aeronave en lo que atañe al cumplimiento del nivel de vuelo.

Aeronave que no satisface los requisitos.
Aeronave cuyo valor absoluto real de TVE, ASE ó AAD es mayor que el valor aceptable para las aeronaves aprobadas para operar en un entorno RVSM

Ocupación.
Parámetro del modelo de riesgo de colisión que equivale al doble del número de pares próximos de aeronaves en una misma dimensión, dividido entre el número total de aeronaves que vuelan en las posibles trayectorias en el mismo intervalo de tiempo.

Error operacional.
Desviación vertical respecto al nivel de vuelo correcto, como resultado de un error del bucle ATC-piloto o de una autorización incorrecta.

Separación vertical planificada.
Distancia planificada que se adopta entre aeronaves en el plano vertical a fin de evitar una colisión.

Error de posición.
Aquella porción del error de fuente estática resultante de la posición de la sonda/puerto estático en la aeronave (ver error de fuente estática).

Error de fuente estática.
Diferencia entre la presión detectada por el sistema estático en el puerto estático y la presión ambiente sin perturbaciones en una condición dada.

Corrección del error de fuente estática (SSEC).
Corrección que se puede aplicar para compensar el error de fuente estática asociado con una aeronave.

Error técnico.
Se refiere a los errores del sistema altimétrico o a los errores técnicos de vuelo.

Nivel deseado de seguridad (TLS).
Término genérico que representa el nivel de riesgo que se considera aceptable en circunstancias particulares.

Error vertical total (TVE).
Diferencia geométrica vertical entre la altitud de presión real de vuelo de una aeronave y su altitud de presión asignada (nivel de vuelo).

Frecuencia de encuentro vertical.
Frecuencia de casos en que dos aeronaves se hallan en superposición longitudinal al viajar en sentidos opuestos o en el mismo sentido por la misma ruta en niveles de vuelo adyacentes y con la separación vertical planificada.

PARTE 1 – INTRODUCCION

1.1 Antecedentes

1.1.1 A mediados de la década de 1970, la escasez mundial de combustibles y la escalada en los costos de los mismos destacaron la necesidad de hacer un uso más eficiente del espacio aéreo. Estas fuerzas resaltaron la necesidad de una evaluación pormenorizada de la factibilidad de reducir la separación vertical mínima (VSM) por encima del nivel de vuelo (FL) 290, de 600 m (2000 ft) a 300 m (1000 ft). Así, en su cuarta reunión (realizada en 1980), el Grupo de Expertos sobre el Examen del Concepto General de Separación (RGCSP) de la Organización de Aviación Civil Internacional (OACI) concluyó que, a pesar del costo y tiempo involucrados, los beneficios potenciales de esta medida eran tan grandes que se debería alentar a los Estados a llevar a cabo las evaluaciones necesarias.

1.1.2 En 1982, con la coordinación del RGCSP, los Estados iniciaron programas completos a fin de estudiar la cuestión de la reducción de la VSM por encima del FL 290. Los estudios fueron llevados a cabo por ocho Estados: Canadá, Japón, Francia, la ex-República Federal de Alemania, el Reino de los Países Bajos, el Reino Unido, la ex-Unión de Repúblicas Socialistas Soviéticas y Estados Unidos de Norteamérica. En diciembre de 1988, los resultados fueron presentados al RGCSP en su sexta reunión (RGCSP/6).

1.1.3 En dichos estudios, se empleó métodos cuantitativos de evaluación del riesgo en apoyo de las decisiones operacionales relativas a la factibilidad de reducir la VSM. La evaluación de riesgo comprendía dos elementos. Primero, el cálculo del riesgo, que consiste en desarrollar y utilizar métodos y técnicas que permiten calcular el nivel real de riego de una actividad; y segundo, la evaluación del riesgo, que involucra el nivel de riesgo que se considera como el valor máximo admisible para un sistema seguro. El nivel de riesgo que se considera aceptable se denomina nivel deseado de seguridad (TLS).

1.1.4 Como parte del proceso de cálculo del riesgo para al plano vertical, se determinó la precisión de performance de mantenimiento de altitud de la población de aeronaves que operaban en el FL 290 ó a niveles superiores. Esto se logró mediante el uso de radares de alta precisión para determinar la altura geométrica real de las aeronaves en vuelo horizontal y en línea recta. Luego, se comparó la altitud de la aeronave medida por radar con la altitud geométrica del nivel de vuelo asignado a la aeronave, a fin de determinar el error vertical total (TVE) de la aeronave en cuestión. Con este conocimiento sobre la población de aeronaves, fue posible calcular el riesgo de colisión resultante únicamente de errores de navegación vertical de las aeronaves a las que se había aplicado en forma correcta una separación vertical de procedimiento. Asimismo, si bien se derivó la evaluación del TLS por el RGCSP para ser aplicada únicamente a esta contribución al riesgo de colisión, no incluyó los aportes de otras fuentes de riesgo de colisión vertical, tales como los descensos de emergencia o cualquier forma de error humano.

1.1.5 El reconocimiento de la existencia de diversas fuentes de error de riesgo vertical, además de los errores de navegación vertical, influyó en la selección de los valores TLS por parte de los Estados durante sus estudios. Se ha seguido diversos métodos para establecer una gama apropiada de valores, entre ellos, el considerar todas las colisiones en vuelo en ruta y el período implícito entre colisiones, y ajustar el TLS hasta que el período de tiempo resulte aceptable. No obstante, el método principal, que también es el tradicional, consistió en la utilización de los datos históricos provenientes de fuentes mundiales, proyectados hasta alrededor del año 2000, a fin de mejorar la seguridad operacional y asignar los presupuestos de riesgo resultantes para derivar el elemento de riesgo de colisión vertical.

1.1.6 Los valores derivados correspondientes al TLS oscilaban entre 1×10^{-8} y 1×10^{-9} accidentes fatales por hora de vuelo. Basándose en estas cifras, el RGCSP utilizó un TLS de evaluación de

2.5×10^{-9} accidentes fatales por hora de vuelo de aeronave para evaluar la factibilidad técnica de una VSM de 300 m (1000 ft) por encima del FL 290. Ese mismo TLS fue utilizado para desarrollar los requisitos relativos a la capacidad de mantenimiento de altitud de las aeronaves para las operaciones con una VSM de 1000 ft.

1.1.7 Utilizando el TLS de evaluación de 2.5×10^{-9} accidentes fatales por hora de vuelo de aeronave, el RGCSP/6 llegó a la conclusión que una VSM de 300 m (1000 ft) por encima del FL 290 era técnicamente factible. Esta factibilidad técnica se refiere a la capacidad fundamental de los sistemas de mantenimiento de altitud de la aeronave, los cuales pueden ser construidos, mantenidos y operados de tal manera que la performance esperada o característica permita la implantación y uso seguros de una VSM de 300 m (1000 ft) por encima del FL 290. Al llegar a esta conclusión acerca de la factibilidad técnica, el grupo de expertos consideró necesario establecer:

a) requisitos de performance de aeronavegabilidad, incorporados dentro de una especificación completa de performance mínima de los sistemas de la aeronave (MASPS), para todas las aeronaves que apliquen la separación reducida;

b) nuevos procedimientos operacionales; y

c) un método completo de verificación del funcionamiento seguro del sistema.

1.1.8 Durante la séptima reunión del RGCSP (noviembre de 1990), el grupo de expertos concluyó el material de orientación mundial sobre la implantación de la separación vertical mínima reducida (RVSM) de 1000 pies. El principal objetivo del material (Doc 9574) era proporcionar a los grupos regionales de planificación (RPG) los criterios, requisitos y la metodología para el desarrollo de los documentos, procedimientos y programas que permitieran la introducción de la RVSM en sus respectivas regiones. El grupo de expertos también observó que los RPG tendrían que realizar un trabajo detallado ulterior para establecer las condiciones para la implantación de la RVSM en cada región individualmente, y que cualquier enmienda a los Procedimientos Suplementarios Regionales de la OACI (Doc 7030) tendría que ser desarrollada por el RPG interesado. El grupo de expertos resaltó especialmente la necesidad de que los RPG aplicaran su criterio operacional al momento de determinar el nivel admisible de riesgo atribuible a aquellas causas de error no incluidas en el TLS global (es decir, el TLS de evaluación de 2.5×10^{-9}). El grupo de expertos también consideró que la Región NAT sería la apropiada para la implantación anticipada de la RVSM debido al flujo básicamente unidireccional del tránsito NAT y a que la población de aeronaves que cumplen con la especificación de performance mínima de navegación (MNPS) ostenta una precisión de mantenimiento de altitud superior al promedio.

1.1.9 En forma paralela al trabajo del RGCSP, en mayo de 1990, el Grupo sobre Planeamiento de Sistemas Atlántico Septentrional (NAT SPG) inició estudios (NAT SPG/26) para la aplicación de la RVSM en la Región NAT. Durante su vigésimo séptima reunión (junio de 1991), el NAT SPG acordó que:

a) la RVSM debería implantarse dentro del ámbito del espacio aéreo MNPS existente;

b) las áreas de transición debería tener una extensión vertical del FL 290 al FL 410 inclusive; estar contenidas dentro de las dimensiones horizontales determinadas por los Estados proveedores ya sea individualmente o previa consulta; estar adyacentes o superpuestas al espacio aéreo MNPS o estar contenidas dentro del mismo; y, en la medida de lo posible, contar con cobertura radar y comunicaciones directas controlador/piloto;

c) sería necesario adoptar una definición más amplia de riesgo vertical que incluya a todas las fuentes de error. La definición incluiría los errores del equipo para los cuales se hubieren desarrollado MASPS, así como los errores operacionales del piloto y del controlador. En consecuencia, se acordó que el TLS debía aumentarse de 2.5 x 10^{-9} a 5 x 10^{-9} a fin de ser consistentes con la nueva definición. El NAT SPG concluyó (Conclusión 27/22) que:

i) el TLS para el riesgo de colisión en la dimensión vertical debido a todas las causas sería 5 x 10^{-9} accidentes fatales por hora de vuelo, y que el riesgo de colisión total en el plano vertical debía evaluarse en base a este TLS; y

ii) el TLS no debía dividirse en componentes separados para los distintos tipos de riesgo. No obstante, sería necesario evaluar la performance de mantenimiento de altitud en relación a un nivel restringido de seguridad operacional de 2.5 X 10^{-9}, ya que este es el valor que ha sido utilizado para obtener la MASPS.

1.1.10 La MASPS fue desarrollada por grupos de expertos que tradujeron los requisitos de distribución del TVE en especificaciones y procedimientos detallados que rigen las normas de mantenimiento de altitud de las aeronaves que operan en el espacio aéreo RVSM. Las especificaciones y procedimientos detallados fueron desarrollados para ser utilizados por los diseñadores, fabricantes, explotadores y autoridades encargadas de otorgar las aprobaciones, y son aplicables a la aprobación de aeronavegabilidad de grupos de aeronaves o de aeronaves individuales.

1.1.11 La Décima Reunión del GREPECAS, realizada en 2001, concluyó (Conclusión 10/11) que el Grupo de Tarea RVSM del ATM/CNS/SG debería llevar a cabo la implantación de la RVSM en las Regiones del Caribe y Sudamérica. Esta conclusión inicial especificaba que la RVSM debía ser implantada en dos fases: la primera, en abril de 2004, entre el FL350 y FL390; y la segunda incluiría las altitudes restantes (del FL290 al FL410, inclusive) en una fecha por definirse.

1.1.12 La tercera reunión de Autoridades y Planificadores de la Gestión del Tránsito Aéreo (AP/ATM/3) llegó a la conclusión (Conclusión 3/18) que el Grupo de Tarea RVSM debía estudiar la posibilidad de armonizar los programas de implantación de la RVSM de las Regiones CAR/SAM y de Estados Unidos. Asimismo, observó que se podría utilizar el Proyecto PNUD/OACI RLA/98/003 como mecanismo para ayudar a los Estados en la implantación de la RVSM en las Regiones CAR/SAM.

1.1.13 Este material de orientación ha sido desarrollado para las Regiones del Caribe y Sudamérica, en base al Manual de Implantación de una Separación Vertical Mínima Reducida (Doc 9574 de la OACI), al trabajo que actualmente realiza el RGCSP, al Doc 002 NAT, y al Material de Orientación sobre la Implantación de una Separación Vertical Mínima de 300 m (1000 ft) entre el FL290 y FL410 Inclusive para su Aplicación en el Espacio Aéreo de la Región Asia/Pacífico. Este material también toma en cuenta la experiencia adquirida en la implantación de la RVSM en las Regiones NAT y Asia/Pacífico, la cual se realizó en tres fases:

Fase de verificación. La región continúa operando con una VSM de 2000 ft mientras se recolecta datos para verificar que el sistema puede operar en forma segura con una VSM de 1000 ft.

Fase de ensayo. Se inicia las operaciones con 1000 ft, y se vigila todos los sistemas para asegurar una operación segura.

Fase operacional. Plena implantación de la RVSM. Continúan la vigilancia y la evaluación del riesgo para crear confianza en la segura y continua operación de la RVSM.

1.2 Alcance y propósito del documento

1.2.1 Este documento busca abordar todos los aspectos de la implantación y operación de una VSM de 1000 ft dentro de las Regiones del Caribe y Sudamérica. Las rutas y espacios aéreos designados para operaciones RVSM serán especificados mediante NOTAM y publicados en los Procedimientos Suplementarios Regionales de la OACI (Doc 7030).

1.2.2 Las aeronaves que pretendan operar aplicando la RVSM tendrán que llevar a bordo y utilizar el equipo descrito en la MASPS RVSM. Esta MASPS ha sido desarrollada con el fin de lograr un nivel mínimo de precisión de navegación vertical o performance de mantenimiento de altitud que permita la introducción de la RVSM de 1000 ft.

1.2.3 Este material de orientación tiene como finalidad:

a) consolidar el material de orientación del RGCSP sobre la implantación de una VSM de 300 m (1000 ft), a fin de cumplir con las exigencias particulares del espacio aéreo del Caribe y Sudamérica;

b) brindar orientación a las autoridades de aviación de los Estados en cuanto a las medidas necesarias para asegurar el cumplimiento de los criterios y requisitos en sus diversas áreas de responsabilidad (por ejemplo, provisión de servicios ATC, aprobación de aeronavegabilidad y vigilancia del espacio aéreo);

c) brindar a los explotadores información que les permita cumplir con los requisitos para operar en espacio aéreo RVSM y ayudar en la elaboración de manuales de operaciones y de procedimientos para la tripulación de vuelo; y

d) constituirse en un documento de referencia básico a ser utilizado por las autoridades de los Estados para el desarrollo de procedimientos y documentación para la aprobación de aeronaves y explotadores.

PARTE 2 – OPERACION DEL ESPACIO AEREO RVSM

2.1 Requisitos básicos

2.1.1 La principal consideración para la introducción y operación continua de la RVSM de 1000 ft en las Regiones del Caribe y Sudamérica es que el riesgo de colisión como consecuencia de una pérdida de separación vertical, sea cual fuere la causa, debe ser inferior al TLS acordado de 5×10^{-9} accidentes fatales por hora de vuelo. Esta condición trae consigo los siguientes requisitos básicos:

a) Todas las aeronaves que pretendan operar en espacio aéreo RVSM deben estar equipadas y ser mantenidas de acuerdo con la MASPS y los respectivos procedimientos de aeronavegabilidad del Estado. La Parte 3 y los apéndices ofrecen la orientación apropiada.

b) Todas las aeronaves que pretendan operar en espacio aéreo RVSM deben contar con la aprobación específica para dichas operaciones, otorgada ya sea por la autoridad aeronáutica del Estado de matrícula de la aeronave o por la autoridad aeronáutica del explotador. La aprobación incluirá el equipamiento y mantenimiento de la aeronave, los procedimientos de aeronavegabilidad, la instrucción de las tripulaciones de vuelo y los procedimientos de operaciones. La responsabilidad de obtener la aprobación necesaria recae en el explotador de la aeronave. Sin embargo, las autoridades aeronáuticas del Estado deberán realizar verificaciones regulares y mantener registros de las aprobaciones que hubieren otorgado. La orientación pertinente aparece en la Parte 4.

c) La tripulación de vuelo debería operar la aeronave de acuerdo con los procedimientos de operaciones recomendados. Estos procedimientos serán aprobados por la autoridad estatal correspondiente y deberían basarse en el material contenido en la Parte 5.

d) Los Estados proveedores ATS tendrán la responsabilidad de desarrollar los procedimientos necesarios para dar apoyo a la RVSM. La Parte 6 de este documento brinda orientación adicional. Los Estados proveedores ATS deberían estar conscientes que la transición desde/hacia el espacio aéreo de 2000 ft adyacente debería efectuarse, en la medida de lo posible, dentro de la cobertura radar y donde se cuente con comunicaciones directas controlador/piloto.

e) El quinto requisito básico consiste en un método para vigilar la performance del sistema para asegurar que las medidas arriba indicadas tengan el efecto deseado (es decir, el cumplimiento del TLS). Debido a que el TLS vertical comprende todas las causas de riesgo vertical, es importante notificar todas las desviaciones conocidas de la altitud asignada (AAD). Entre las fuentes de información, figuran:

   i) los datos de los sistemas de vigilancia de altitud;

   ii) las desviaciones AAD del Modo C reportadas por el control de tránsito aéreo (ATC);

   iii) los informes ordinarios de posición al ATC, que identifican las operaciones que se realizan en niveles de vuelo incorrectos;

   iv) los informes de incidentes; y

   v) la recolección específica de datos (por ejemplo, registradores digitales de datos de vuelo de a bordo, Modo C, etc.).

2.1.2 Es sumamente importante que los proveedores ATS registren y notifiquen todos los casos de desviaciones de altitud en las Regiones del Caribe y Sudamérica a la agencia regional de monitoreo. El detalle de los procedimientos aparece en la Parte 8 de este documento.

2.2 La Especificación de Performance del Sistema Global y la MASPS RVSM

2.2.1 Si bien la Región NAT fue la primera en implantar la RVSM, se anticipaba que otras regiones harían lo mismo. Al desarrollar los requisitos para las operaciones RVSM, el RGCSP tomó en cuenta las condiciones a nivel mundial. Es importante aplicar especificaciones uniformes en todo el espacio RVSM, especialmente con respecto a la performance de la aeronave. Por lo tanto, los requisitos de performance de mantenimiento de altitud de la aeronave aplicados en la Región NAT y que se aplicarán en las Regiones del Caribe y Sudamérica estarán basados en los requisitos mundiales desarrollados por el RGCSP. Un objetivo secundario importante durante la implantación de la RVSM en las Regiones del Caribe y Sudamérica será demostrar que es posible cumplir con los requisitos mundiales.

2.2.2 Para poder determinar los requisitos de performance de mantenimiento de altitud de las aeronaves a ser utilizadas en un ambiente RVSM, se requiere tres datos: el TLS, la frecuencia de encuentro vertical y la precisión de navegación lateral de la población de aeronaves.

2.2.3 Como se explicó en la introducción, el TLS desarrollado por el RGCSP para la implantación de la RVSM a nivel mundial es 2.5×10^{-9} accidentes fatales por hora de vuelo. Este valor TLS se aplica al riesgo de colisión asociado con la performance de navegación vertical, denominado "performance de mantenimiento de altitud". No contempla el riesgo resultante de errores en las instrucciones del ATC o de la pérdida de separación vertical asociada con emergencias durante el vuelo.

2.2.4 La frecuencia de encuentro vertical es una medida de la cantidad de veces que las aeronaves se encuentran en niveles de vuelo adyacentes con la separación vertical planificada. Este parámetro refleja tanto la densidad como los patrones de tránsito, y su valor varía considerablemente de una región a otra. Cuanto mayor el valor de la frecuencia de encuentro, mayor será el riesgo de colisión por hora de vuelo. A fin de asegurar que la performance de mantenimiento de altitud requerida garantizaría operaciones RVSM seguras en cualquier región, fue necesario elegir un valor para la frecuencia de encuentro vertical que tuviera pocas probabilidades de ser excedido en cualquier espacio aéreo durante cierto tiempo. Se consideró que una frecuencia equivalente de encuentro en direcciones opuestas[1] de 2.5 por hora de vuelo sería apropiada para cualquier espacio aéreo hasta el año 2005. (Como referencia, la frecuencia equivalente de encuentro en direcciones opuestas para la Región NAT en 1994 fue de aproximadamente 0.25.)

2.2.5 La precisión de navegación lateral tiene un impacto sobre el riesgo de colisión vertical, ya que este parámetro determina la magnitud de la probabilidad de superposición lateral entre dos aeronaves que se hallan nominalmente en la misma derrota. Por lo tanto, cuanto mejor la precisión de navegación lateral, mayor será el riesgo vertical. Para calcular los requisitos globales de performance en relación a la capacidad técnica de mantenimiento de altitud, el RGCSP eligió un valor no menor de 0.3 NM para la desviación característica de la precisión de navegación lateral. Se consideró que este valor era apropiado para la navegación en ruta hasta el año 2005. (Como referencia, en 1991, se calculó una desviación característica de la precisión de navegación lateral de 1.76 NM para el espacio aéreo MNPS NAT.)

2.2.6 Utilizando estos valores para el TLS, la frecuencia de encuentro y la precisión de navegación lateral, se puede calcular el valor máximo admisible para la probabilidad de superposición vertical (es

[1] Las frecuencias de encuentro pueden dividirse en frecuencias de encuentro en la misma dirección y en direcciones opuestas. Estos dos componentes pueden ser combinados para obtener una frecuencia equivalente de encuentro en direcciones opuestas que hace la misma contribución al riesgo de colisión.

decir, la probabilidad que dos aeronaves nominalmente separadas por una norma de separación se hallen, en realidad, en superposición vertical). El valor de la probabilidad de superposición vertical está determinado por la performance de mantenimiento de altitud de la población de aeronaves. El RGCSP obtuvo un valor de 1.7×10^{-8}.

2.2.7 En conjunto, la frecuencia de encuentro, la probabilidad de superposición lateral y la probabilidad de superposición vertical conforman la especificación de performance del sistema global. Se les considera como parámetros críticos que caracterizan a un espacio aéreo de condiciones adversas extremas en términos de riesgo de colisión vertical. Los niveles de estos parámetros fueron fijados de manera que pudieran perdurar hasta el año 2005. La especificación también define la performance de mantenimiento de altitud requerida de las aeronaves para que el riesgo de colisión en dicho espacio aéreo de condiciones adversas extremas no exceda 2.5×10^{-9} accidentes fatales por hora de vuelo. La expresión cuantitativa de la especificación de performance del sistema global es:

a) una frecuencia de encuentro igual o inferior al equivalente de 2.5 encuentros en direcciones opuestas por hora de vuelo de aeronave;

b) una desviación característica (SD) del error de mantenimiento lateral de la trayectoria igual o superior a 0.3 NM; y

c) una probabilidad de que dos aeronaves, nominalmente separadas por 1000 pies, se hallen en una superposición vertical, P_z (1000), igual o inferior a 1.7×10^{-8}.

2.2.8 La evaluación del cumplimiento del requisito global de probabilidad de superposición vertical es un proceso matemático complejo. A fin de relacionar estos requisitos con la performance de mantenimiento de altitud de la aeronave, se elaboró una especificación de performance global de mantenimiento de altitud. El conjunto de las performances TVE en el espacio aéreo debe cumplir con esta especificación. La especificación de performance global de mantenimiento de altitud requiere el cumplimiento simultáneo de las cuatro condiciones siguientes:

a) la proporción de TVE de una magnitud superior a 300 ft debe ser inferior a 2.0×10^{-3};

b) la proporción de TVE de una magnitud superior a 500 ft debe ser inferior a 3.5×10^{-6};

c) la proporción de TVE de una magnitud superior a 650 ft debe ser inferior a 1.6×10^{-7};

d) la proporción de TVE de una magnitud entre 950 y 1050 ft debe ser inferior a 1.7×10^{-8}.

2.2.9 Se ha desarrollado una MASPS para garantizar el cumplimiento de los requisitos de la especificación de performance global de mantenimiento de altitud por parte de las aeronaves que operan en las Regiones del Caribe y Sudamérica. La MASPS consiste en especificaciones y procedimientos detallados para los diseñadores, fabricantes, explotadores y autoridades encargadas de otorgar las aprobaciones. Los requisitos de la MASPS aparecen descritos en la Parte 3. Los mecanismos propuestos para comprobar el cumplimiento de los requisitos de la especificación de performance del sistema global aparecen descritos en la Parte 7 de este documento.

2.2.10 Cabe recalcar que el cumplimiento de la especificación de performance del sistema global no garantiza automáticamente el cumplimiento del TLS de 5×10^{-9} accidentes fatales por hora de vuelo para todo el sistema. También se debe vigilar otras fuentes de error, y se debe evaluar el aporte de éstas al riesgo total de colisión.

2.3 Planificación de la vigilancia

2.3.1 El plan para evaluar la performance de mantenimiento de altitud en las Regiones del Caribe y Sudamérica durante el período de verificación y ensayo operacional, así como después de completarse la implantación, toma en cuenta los siguientes factores:

a) el tamaño de la muestra de datos necesaria para evaluar la seguridad operacional de todo el sistema aeroespacial, en base a factores tales como el nivel de confianza estadística;

b) las prioridades en cuanto a los objetivos específicos de vigilancia a fin de obtener de los programas de vigilancia una muestra representativa. Esto incluirá tomar en cuenta las prioridades en cuanto a los tipos de aeronave individuales, los tipos de aeronaves individuales usadas por los explotadores individuales, y células individuales; y

c) la capacidad de vigilar la AAD, los errores operacionales y las desviaciones importantes de altitud.

2.4 Verificación y ensayos

Generalidades

2.4.1 Durante la fase de verificación, cada grupo de aeronaves de cada explotador que no haya recibido previamente aprobación para realizar operaciones RVSM deberá someterse a una verificación de la performance de mantenimiento de altitud. Para ello, la aeronave debería llevar a bordo un Monitor del Sistema Mundial de Determinación de la Posición (GPS) (GMU), ya que no se contará en las regiones con un monitor de altura en un emplazamiento fijo para la verificación y los ensayos en el Caribe y Sudamérica.

Nota: Si bien la aeronave que lleva el GMU a bordo no tiene que estar necesariamente en un vuelo en el Caribe o Sudamérica, deberá utilizarse en un vuelo horizontal entre el FL 290 y FL 410.

2.4.2 Durante los ensayos operacionales y luego de la implantación de la RVSM, cada explotador deberá cooperar con la agencia regional de monitoreo en la recolección de datos sobre la performance de mantenimiento de altitud de cada tipo de aeronave a fin de recibir la aprobación para operar dicho tipo de aeronave en el espacio aéreo RVSM.

Fase de verificación

2.4.3 Antes de implantar la RVSM y mientras se está operando en un ambiente de 2000 ft, será necesario verificar que el nivel de seguridad operacional del sistema RVSM propuesto permanecerá igual o será inferior al TLS. Esta fase de verificación está programada para durar un año, para demostrar que:

a) en un ambiente de 1000 ft, se cumpliría el TLS de 5.0×10^{-9} accidentes fatales por hora de vuelo debidos a la pérdida de separación vertical;

b) la performance de mantenimiento de altitud de las aeronaves aprobadas para operar en un ambiente RVSM cumple con la MASPS mencionada en la Parte 3. Para ello, se deberá verificar que:

  i) las causas de los errores de mantenimiento de altitud que no cumplen con la especificación de performance global de mantenimiento de altitud sean corregidas y que la aeronave sea nuevamente sometida a vigilancia;

  ii) cualquier tendencia adversa o error que pudiera resultar en una performance inaceptable en una aeronave o grupo de aeronaves sea corregida y, de ser necesario, sea nuevamente sometida a vigilancia para constatar el cumplimiento;

  iii) se ponga mayor énfasis en la vigilancia de los grupos de aeronaves que se sabe excedían los requisitos de la MASPS antes de la aplicación de los procedimientos de aeronavegabilidad;

iv) las matrículas de aeronave reportadas a la agencia regional de monitoreo estén debidamente registradas; y

v) el programa de vigilancia de altitud realice observaciones en una muestra de aeronaves y explotadores aprobados para operar en un ambiente RVSM que sea representativa de toda la población, de tal manera que se pueda esperar que las aeronaves no observadas tengan una performance que sea consistente con la MASPS.

c) los procedimientos operacionales adoptados para operaciones RVSM sean efectivos y apropiados; y

d) el programa de vigilancia de altitud sea efectivo.

2.4.4 Los datos recolectados durante la fase de verificación son utilizados para evaluar si el riesgo en el sistema permanecerá en el TLS o a un nivel inferior en el futuro, tomando en cuenta el aumento del tráfico y las mejoras en la navegación lateral como resultado de las nuevas tecnologías.

2.4.5 En base al número de aeronaves aprobadas, se evalúa si la fase de ensayo de la RVSM puede respaldar la implantación de la RVSM en todos los niveles de vuelo entre 290 y 410 inclusive. Al hacer esta evaluación, se debería tomar en cuenta aquellas aeronaves que no están en capacidad de obtener la aprobación.

Fase de ensayo

2.4.6 Luego de la fase de verificación en un ambiente de 2000 ft, habrá un período adicional de ensayo de un año, operando con una separación de 1000 ft. En esta fase de ensayo, continuarán todas las verificaciones realizadas en el ambiente de 2000 ft. La finalidad de esta fase es asegurar que las predicciones y simulaciones realizadas durante la Fase de Verificación reflejen con precisión la verdadera performance del sistema. El sistema operará en forma idéntica a como lo hará en la Fase Operacional, pero la performance y la seguridad operacional serán vigiladas más de cerca a fin de asegurar que no se ha descuidado detalle alguno durante la Fase de Verificación. Los estudios que se efectúen durante esta fase de ensayo serán utilizados para confirmar y, luego, sustentar estadísticamente que el riesgo en el sistema es igual o inferior al TLS, y para evaluar si continuará a ese nivel, tomando en cuenta el aumento del tráfico y las mejoras en la performance de navegación lateral.

2.4.6.1 En esta fase de ensayo, también se intenta demostrar que:

a) las aeronaves no aprobadas están efectivamente excluidas del espacio aéreo RVSM,

b) las causas de los errores del sistema altimétrico (ASE) que exceden los requisitos de la MASPS han sido identificadas y corregidas, y

c) el explotador de cualquier célula que exceda los requisitos ASE sea notificado e impedido de utilizar el espacio aéreo RVSM hasta el problema de performance de la célula haya sido corregido, nuevamente se haya efectuado la vigilancia de la célula y se haya demostrado su cumplimiento con el ASE.

Fase Operacional

2.4.8 Una vez completada la Fase de Ensayo en forma exitosa, se iniciará la Fase Operacional, que implica la operación normal y vigilancia de la performance de la RVSM en las Regiones del Caribe y Sudamérica. La evaluación de la seguridad operacional del sistema se hará en forma anual. Se seguirá recolectando datos sobre la performance de mantenimiento de altitud de las aeronaves en la región a fin de asegurar el cumplimiento con la especificación de performance global. La efectividad del programa de vigilancia será examinada en forma anual.

PARTE 3 - AERONAVEGABILIDAD

3.1 Introducción

3.1.1 Las MASPS han sido publicadas por la Administración Federal de Aviación (FAA) bajo la forma de un texto de orientación provisional (Apéndice A) y por las Autoridades Conjuntas de Aviación (JAA) como un folleto provisional de orientación (Apéndice E). Estos documentos detallan los programas de aeronavegabilidad, mantenimiento de la aeronavegabilidad y de operaciones que se requieren para otorgar la aprobación a explotadores y aeronaves para realizar vuelos en el espacio aéreo donde se aplica la RVSM.

3.1.2 Los requisitos de ingeniería de las aeronaves para la aprobación RVSM de las mismas han sido desarrollados en base a las siguientes características. Para las aeronaves en servicio, los documentos de aprobación de aeronavegabilidad han adoptado la forma de Boletines de Servicio, Cambios de Servicio de las Aeronaves y Certificados de Tipo Suplementario emitidos por los fabricantes de las aeronaves. Estos documentos se encuentran disponibles para la mayoría de las aeronaves en servicio. Los requisitos RVSM también han sido incluidos en el proceso de certificación de las aeronaves fabricadas más recientemente.

3.1.3 Las características fueron desarrolladas de conformidad con las conclusiones de la Reunión RGCSP/6 (Doc 9536 de la OACI), a fin de satisfacer los límites de distribución del TVE y para que el impacto de la aeronavegabilidad de las aeronaves sobre el cumplimiento de los requisitos sea insignificante. Las características son aplicables estadísticamente a grupos individuales de aeronaves nominalmente idénticas que operan en el espacio aéreo. Asimismo, describen la performance que los grupos deben ser capaces de alcanzar en servicio, excluyendo los errores por el factor humano y las influencias ambientales extremas, para poder cumplir con los requisitos TVE del sistema del espacio aéreo. Los requisitos, que sirvieron de base para el desarrollo de la MASPS, son los siguientes:

a) el ASE medio del grupo no deberá exceder ±25 m (±80 ft);

b) la suma del valor absoluto del ASE medio para el grupo mas tres desviaciones características del ASE dentro del grupo no deberá exceder 75 m (245 ft); y

c) los errores de mantenimiento de altitud deberán ser simétricos alrededor de una media de 0 m (0 ft) y deberán tener una desviación característica no mayor de 13 m (43 ft), y deberán permitir que la frecuencia de error disminuya conforme aumenta la magnitud del error a una tasa que sea, por lo menos, exponencial.

3.1.4 Las características arriba indicadas deberán ser utilizadas para establecer las normas de aprobación de tipo en lo referente a la capacidad de diseño, aunque éstas se refieren, básicamente, a la parte central de los requisitos de distribución del TVE. A fin de restringir los aspectos de la distribución de cola correspondientes a la aeronave y al equipo, también será necesario desarrollar especificaciones y procedimientos detallados referidos a la entrega de producción y al mantenimiento de la aeronavegabilidad.

3.2 Aprobación de aeronavegabilidad

Introducción

3.2.1 La aprobación de aeronavegabilidad debe, en todos los casos, satisfacer los requisitos de la MASPS, que incluyen especificaciones y procedimientos relativos a los distintos aspectos de la aprobación de tipo, entrega de producción, y mantenimiento de la aeronavegabilidad. A continuación, se presenta estos distintos aspectos de la aprobación, así como su aplicabilidad a la aprobación de las aeronaves existentes.

3.2.2 Todas las aprobaciones se aplicarán a aeronaves individuales o grupos de aeronaves nominalmente idénticas en lo que atañe a diseño aerodinámico y elementos de equipo que contribuyen a la precisión de mantenimiento de altitud, tal como se define en el párrafo 3.1.3 anterior.

Definición de grupos de tipos de aeronaves

3.2.3 Al agrupar las aeronaves según sus similitudes, desde el punto de vista de la aprobación o evaluación de las normas o requisitos de mantenimiento de altitud, hay que tener presente que las aeronaves con designaciones de tipo o serie muy similares o aparentemente idénticas, en algunos casos, son muy diferentes en cuanto a diseño aerodinámico y equipo de aviónica. Por el contrario, aeronaves con distintas designaciones de serie pueden ser idénticas en todas las características que contribuyen a su capacidad de mantenimiento de altitud.

3.2.4 Por lo tanto, hay que asegurarse que todas las aeronaves que se entiende conforman un grupo tengan un diseño y construcción idénticos con respecto a todos los detalles que podrían afectar la precisión de la performance de mantenimiento de altitud. Todas las aeronaves del mismo grupo tienen que haber sido diseñados y ensamblados por el mismo fabricante. El sistema pitot/estático de las células deberá estar instalado de una manera y en una posición idénticas y, de ser necesario, se deberá incluir las mismas acciones correctivas para cumplir con los requisitos RVSM. Todas las aeronaves en un grupo deberán tener los mismos sistemas de altimetría, mantenimiento de altitud y advertencia de altitud instalados originalmente y deberán ser capaces de satisfacer los requisitos RVSM. Cualquier variación en las mismas con respecto a la instalación inicial deberá contar con la autorización del fabricante de la célula o de una organización de diseño reconocida que certifique que su capacidad de cumplir con la RVSM no ha sido afectada.

3.2.5 Esto no excluye la aprobación por similitud, pero, en caso de existir diferencias, se debería evaluar el posible impacto de todos estos detalles antes de otorgar o extender la aprobación para abarcar dichas variaciones.

Aprobación de tipo de aeronave

3.2.6 Al evaluar un paquete de aprobación, hay que asegurarse que los datos de calibración en vuelo utilizados para evaluar el error de posición residual sean representativos de las aeronaves y de su envolvente operacional típico en el espacio aéreo RVSM. Todas las fuentes y variaciones de error deberían ser tomadas en cuenta en el proceso de aprobación, incluyendo las incertidumbres inherentes a dichos datos de calibración en vuelo. Asimismo, se debería desarrollar datos para las condiciones extremas de operación de las aeronaves en el envolvente operacional RVSM.

3.2.7 La aplicación de buenos métodos de diseño, fabricación, certificación y mantenimiento brinda un nivel de confiabilidad en los equipos que da apoyo a la RVSM. Para asegurar que la integridad del sistema global se mantendrá a un nivel alto, durante el proceso de aprobación de aeronavegabilidad, se debería demostrar analíticamente que la ocurrencia de fallas no detectadas en el sistema altimétrico será inferior a 1×10^{-5} por hora de vuelo. En este análisis, se puede tomar en cuenta el requisito de contar con sistemas altimétricos redundantes y la capacidad de la tripulación de vuelo de detectar fallas en el sistema altimétrico mediante procedimientos de verificación cruzada.

Puesta en circulación de la producción

3.2.8 La MASP incorpora especificaciones y procedimientos que garantizan que cada una de las aeronaves incluidas en una aprobación grupal, que han sido fabricadas o modificadas para satisfacer las normas de aprobación con posterioridad al otorgamiento de dicha aprobación, cumplan con los requisitos. Idealmente, estos procedimientos incluirían una prueba en vuelo en todas las aeronaves, por lo menos en un punto del envolvente operacional, a fin de demostrar la similitud en la producción. Es posible moderar los requisitos de la prueba en vuelo hasta un nivel apropiado de prueba por muestreo, dependiendo del nivel de repetibilidad productiva que el fabricante pueda convalidar. Se podría utilizar datos ya existentes obtenidos de las mediciones del TVE para demostrar la capacidad de repetibilidad productiva de un determinado fabricante. En ese caso, también se debe demostrar que las incertidumbres asociadas con los datos, incluyendo su aplicabilidad al grupo específico de aeronaves en cuestión, no invalidan las conclusiones.

Mantenimiento de la aeronavegabilidad

3.2.9 Se debería desarrollar especificaciones y procedimientos, que luego serían incorporados en los requisitos de mantenimiento de la MASPS, que garanticen que cada una de las aeronaves, a lo largo de su vida útil, sigue cumpliendo con los requisitos desarrollados de conformidad con el párrafo 3.1 anterior. Estos procedimientos deberían incluir algún tipo de prueba periódica en vuelo para demostrar su precisión de mantenimiento de altitud. El texto de orientación provisional que aparece en el Apéndice A ilustra estos procedimientos. Podría resultar aceptable utilizar instalaciones independientes de vigilancia del TVE para cumplir con este requisito, siempre y cuando se demuestre que los errores e incertidumbres asociados con las mediciones cumplen con los requisitos, y se pueda evaluar las contribuciones individuales de la célula, la aviónica y el error técnico de vuelo (FTE) al TVE. La periodicidad requerida no será necesariamente igual para todas las aeronaves, y se puede utilizar datos existentes obtenidos de mediciones del TVE para determinar el intervalo de convalidación apropiado.

Aprobación de aeronaves existentes

3.2.10 A continuación, se ofrece orientación sobre la forma como se deben aplicar los elementos de la MASPS:

a) Aprobación de tipo. Se aplica los requisitos de la MASPS que aparecen en el Apéndice A. En muchos casos, es probable que ya existan suficientes datos de pruebas en vuelo provenientes del programa de desarrollo de tipo para satisfacer esa parte de los requisitos de aprobación. En otros casos, se puede utilizar datos independientes sobre el TVE para cumplir con los requisitos de aprobación de la prueba en vuelo. En este caso, se puede hacer una evaluación detallada de los grupos de tipo en los que son aplicables dichos datos, demostrando que los errores e incertidumbres asociados con dichos datos satisfacen los requisitos. Si los datos originales de la prueba en vuelo y los datos independientes del TVE son insuficientes para cumplir con los requisitos de aprobación, entonces será necesario generar nuevos datos. Cuando se evalúa la capacidad de diseño en base a datos obtenidos de aeronaves que han estado en servicio por un período prolongado, se permite una tolerancia por concepto de degradación por envejecimiento atribuible al ASE, dentro de los límites establecidos por el acápite b) del párrafo 3.1.2 anterior. Los expertos deberían evaluar si también hay efectos de envejecimiento atribuibles a los sistemas de piloto automático. Cuando se utiliza datos de performance para evaluar la capacidad de diseño, será necesario recolectar datos más extensos, para un determinado nivel de confianza, de lo que sería necesario si se pudiera evaluar la capacidad de diseño en forma directa.

b) Control de repetibilidad y mantenimiento de la aeronavegabilidad

    i) Para las aeronaves en servicio, será necesario considerar los requisitos de los párrafos 3.2.8 y 3.2.9 en forma conjunta. En muchas de las aeronaves existentes, es poco probable que se pueda demostrar la aplicación de los controles de entrega de producción mencionados en el párrafo 3.2.8, pero bien se podría cumplir con los objetivos de dichos requisitos en las aeronaves que han estado en servicio por un tiempo prolongado, mediante los requisitos de mantenimiento de la aeronavegabilidad del párrafo 3.2.9. Antes de recibir la aprobación, dichas aeronaves deberían someterse, individualmente, a las verificaciones apropiadas de mantenimiento de la aeronavegabilidad desarrolladas según el párrafo 3.2.9 anterior y cumplir con los requisitos de aprobación de tipo.

ii) Para las aeronaves con poco tiempo de servicio, es aceptable asumir que se ha logrado la repetibilidad productiva normal, excepto cuando existen evidencias de variaciones inusualmente significativas. Debería ser obligatorio revelar dicha evidencia. La conversión de dicha evidencia --en caso de exista con respecto a algunas aeronaves en base a datos independientes del TVE-- a requisitos de aprobación adicionales y específicos dependerá de cuán bien el fabricante y/o explotador puede identificar la fuente del problema y si se determina que tiene su origen en la producción o en la operación.

Nota: Las definiciones de "tiempo prolongado" y "poco tiempo de servicio", tal como se utilizan en los párrafos anteriores, deberían ser interpretadas en relación al intervalo apropiado de convalidación del mantenimiento de la aeronavegabilidad desarrollado según el párrafo 3.2.9.

PARTE 4 – APROBACION ESTATAL DE LAS AERONAVES PARA OPERACIONES RVSM

4.1 Proceso de aprobación

4.1.1 A partir de una fecha efectiva acordada, las aeronaves que operen en espacio aéreo designado dentro de las Regiones del Caribe y Sudamérica y que deseen obtener los beneficios de la RVSM deberán obtener una aprobación para realizar dichas operaciones. El explotador de la aeronave es quien tiene la responsabilidad de obtener la aprobación necesaria. No obstante, las autoridades aeronáuticas del Estado deberían realizar verificaciones regulares y mantener un registro de las aprobaciones otorgadas. La aprobación incluye: 1) la aprobación de la aeronavegabilidad, incluyendo el mantenimiento de la misma, 2) la aprobación operacional, y 3) disposiciones para la vigilancia.

4.2 Aprobación y mantenimiento de la aeronavegabilidad

4.2.1 Las autoridades de aeronavegabilidad del Estado otorgan la aprobación para operar en el espacio aéreo RVSM a las aeronaves que cumplen con los requisitos de mantenimiento de altitud.

4.2.2 Asimismo, los explotadores de aeronaves deben contar con equipos altimétricos y de mantenimiento de altitud, de acuerdo con los procedimientos y cronogramas de servicio aprobados.

4.3 Aprobación operacional

4.3.1 Cada tipo o grupo de aeronaves y cada célula a ser utilizados en las operaciones RVSM deben obtener la aprobación de aeronavegabilidad. Las autoridades que otorgan la aprobación operacional deberían evaluar los documentos de aeronavegabilidad para cada tipo o grupo y para cada célula. En la mayoría de los casos, se espera que los documentos de aeronavegabilidad le den a la autoridad la seguridad que el mantenimiento de altitud se aplicará a los niveles requeridos. En ciertos casos, puede que el explotador tenga que demostrar la performance de mantenimiento de altitud para el tipo de aeronave.

4.3.2 La autoridad encargada de otorgar la aprobación debe estar convencida que los programas operacionales son adecuados. Se debería evaluar la instrucción de las tripulaciones de vuelo, así como los manuales de operaciones.

4.3.3 Cada tipo o grupo de aeronaves deberá recibir la aprobación operacional para realizar operaciones RVSM. Cada aeronave deberá recibir la aprobación de aeronavegabilidad antes de ser aprobada para su utilización por parte del explotador.

4.3.4 Las autoridades encargadas de emitir las aprobaciones deben desarrollar procedimientos que les sirvan de base confiable para otorgar la aprobación operacional según el párrafo 3.2.10 b) anterior.

4.3.5 Si la experiencia operacional demuestra que la performance de mantenimiento de altitud de un determinado tipo de aeronave utilizado por un explotador excede los requisitos de los párrafos 3.1.3 b) y c) anteriores, el explotador debería estar obligado a tomar medidas para mejorar la performance hasta los niveles requeridos. Si no mejora la performance, entonces se debería retirar la aprobación operacional para el tipo de aeronave. En aquellos casos en que se observa un grave error en la performance de mantenimiento de altitud, se debería retirar la aprobación de inmediato.

4.4 Disposiciones para la vigilancia de las aeronaves

4.4.1 El explotador debería elaborar un plan para participar en el programa de verificación/vigilancia de la performance de mantenimiento de altitud de las aeronaves.

Normalmente, este programa debería incluir la verificación de, por lo menos, una parte de las aeronaves del explotador mediante un sistema independiente de vigilancia de altitud. Se considera que este programa es un elemento necesario para la implantación de la RVSM. Los programas de verificación y vigilancia tienen como objetivo principal observar y evaluar la performance de mantenimiento de altitud de las aeronaves, a fin de tener la certeza que los usuarios del espacio aéreo están llevando a cabo el proceso de aprobación de aeronaves y/o explotadores en forma efectiva, y que, cuando se implante la RVSM, se mantendrá la seguridad operacional. Se anticipa que la necesidad de un programa semejante disminuirá o, posiblemente, desaparecerá una vez que se tenga la certeza que el programa RVSM está funcionando de la manera esperada.

4.5 Base de datos nacional (SDB)

4.5.1 A fin de lograr una vigilancia adecuada del espacio aéreo RVSM en el plano vertical, las autoridades aeronáuticas estatales deberán mantener una SDB de todas las aprobaciones que hubieren otorgado para la realización de operaciones dentro del espacio aéreo RVSM. Los detalles acerca de la compilación y formateo de los datos y de los parámetros operacionales del sistema están en proceso de desarrollo. Idealmente, las SDBs aportarán información a la agencia regional de monitoreo en forma regular, lo cual facilitará la vigilancia táctica de la situación de aprobación de las aeronaves y la exclusión de los usuarios no aprobados. La Agencia de Vigilancia del Caribe y Sudamérica (CARSAMMA) es de autoridad regional de vigilancia para las Regiones del Caribe y Sudamérica.

4.6 Información sobre vigilancia y bases de datos en el sitio *web* de la CARSAMMA

4.6.1 *El sitio web de la CARSAMMA está en proceso de elaboración; entretanto* – El sitio *web* RVSM de la FAA contiene información actualizada sobre los requisitos y procedimientos de vigilancia y de base de datos. La dirección del sitio *web* es ***www.faa.gov/ats/ato/rvsm1.htm***.

PARTE 5 – PROCEDIMIENTOS OPERACIONALES PARA LA TRIPULACION DE VUELO

5.1 Introducción

5.1.1 Por regla general, los procedimientos operacionales para la tripulación de vuelo en el espacio aéreo RVSM no son diferentes a los que se aplican en otros espacios aéreos; sin embargo, la implantación de la RVSM puede exigir que se modifiquen algunos procedimientos, como, por ejemplo, los procedimientos de contingencia (Parte 7). Dados los requisitos en materia de seguridad operacional y el efecto que las desviaciones importantes de altitud podrían tener en los niveles de riesgo, debería advertirse a las tripulaciones que deben ejercer una mayor vigilancia para reducir al mínimo los casos de desviaciones respecto al nivel de vuelo asignado. En consecuencia, durante la instrucción de rutina, debería advertirse a las tripulaciones de vuelo acerca de la importancia de aplicar los siguientes procedimientos durante el vuelo.

5.1.1 El Apéndice 4 del Texto de Orientación Provisional de la FAA (91-RVSM) o el Folleto Provisional de Orientación - 6 de la JAA (TGL-6), que se adjuntan a este material de orientación, deberían servir de base para el desarrollo de programas de instrucción de pilotos y, de ser el caso, de despachadores para operaciones normales. El Apéndice 5 del Texto de Orientación Provisional de la FAA debería servir de base para la instrucción de pilotos y, de ser el caso, de despachadores en materia de procedimientos de contingencia para las operaciones.

5.1.2 Asimismo, los explotadores deben incluir en los programas de instrucción los procedimientos y la información relativos a la operación RVSM publicados en los NOTAM y en las Publicaciones de Información Aeronáutica de los Estados.

5.2 Procedimientos en vuelo dentro del espacio aéreo RVSM

5.2.1 Antes de ingresar al espacio aéreo RVSM, el piloto debería revisar las condiciones en que se encuentra el equipo requerido. El equipo siguiente debería estar funcionando en forma normal:

a) dos sistemas altimétricos primarios;

b) un dispositivo automático de mantenimiento de altitud; y

c) un dispositivo de alerta de altitud.

5.2.2 En caso de falla de alguno de los equipos requeridos antes del ingreso de la aeronave al espacio aéreo RVSM, el piloto debería solicitar una nueva autorización para evitar volar en dicho espacio aéreo.

5.2.3 Durante el vuelo, se debería adoptar las siguientes acciones:

a) se debería poner énfasis en el rápido reglaje de la sub-escala de todos los altímetros primarios a 29.92 pulgadasHg/1013.2 hPa al atravesar la altitud de transición, y en la verificación nuevamente del correcto reglaje del altímetro al llegar al nivel de vuelo inicial autorizado (CFL);

b) cuando esté en crucero en vuelo horizontal, es fundamental que la aeronave se mantenga en el CFL. Esto exige especial cuidado a fin de asegurar que se entiendan bien y se acaten las autorizaciones del ATC. Salvo en caso de emergencia, la aeronave no debería salirse intencionalmente del CFL sin una autorización positiva del ATC;

c) durante la transición autorizada entre niveles, la aeronave no debería alejarse más de 45 m (150 ft) por encima o por debajo del viejo o del nuevo nivel de vuelo;

d) durante el crucero en vuelo horizontal, debería haber un dispositivo de mantenimiento de altitud (AKD) operativo y activado, salvo cuando circunstancias tales como la necesidad de modificar la compensación de la aeronave o turbulencia exijan su desactivación. En todo caso, el mantenimiento de la altitud de crucero debería efectuarse tomando como referencia uno de los dos altímetros primarios;

e) el dispositivo de alerta de altitud debería estar operativo y activado;

f) a intervalos de una hora aproximadamente, se debería verificar los altímetros primarios en forma cruzada. Al menos dos de ellos deben coincidir dentro de un margen de 60 m (200 ft). De no respetarse esta condición, deberá declararse defectuoso el sistema altimétrico, notificándose al ATC;

Nota: Se debería considerar el uso del tercer altímetro, en caso de estar instalado, como una forma de mantener el sistema operativo. Los sistemas futuros podrán utilizar comparadores altimétricos en vez de verificaciones regulares.

g) el transpondedor de notificación de altitud que esté en funcionamiento debería estar conectado al sistema altimétrico que se esté utilizando para controlar la aeronave;

h) el piloto debería notificar al ATC acerca de las contingencias (fallas del equipo, condiciones meteorológicas) que afecten su capacidad de mantener su CFL y coordinar un plan de acción. Si no puede notificar al ATC y obtener una autorización del mismo antes de desviarse del CFL, el piloto debería seguir los procedimientos de contingencia establecidos que aparecen detallados en la Parte 7 para alejarse de la ruta o derrota asignada y obtener la autorización del ATC a la brevedad posible. Algunos ejemplos de fallas de equipo y condiciones meteorológicas que deberían ser notificadas al ATC son:

   i) falla de todos los AKD automáticos a bordo de la aeronave;

   ii) pérdida de redundancia de los sistemas altimétricos, o cualquier parte de los mismos, a bordo de la aeronave;

   iii) pérdida de empuje en un motor, haciendo necesario un descenso;

   iv) cualquier otra falla del equipo que afecte la capacidad de mantener el CFL; y

   v) una turbulencia más que moderada.

i) Los pilotos deberían utilizar la frase " RVSM IMPOSIBLE DEBIDO EQUIPO" para indicarle al ATC que la aeronave no cumple los requisitos para operar dentro del espacio aéreo designado para operaciones RVSM.

Nota: La Parte 7 contiene los procedimientos de contingencia específicos para las tripulaciones de vuelo y los controladores.

5.3 Puntos en los que se debe poner especial énfasis: instrucción de las tripulaciones de vuelo

5.3.1 Los programas de instrucción de las tripulaciones de vuelo deberían poner énfasis en los siguientes puntos:

a) conocimiento y comprensión de la fraseología ATC normalizada utilizada en cada área de operaciones;

b) la importancia de una verificación cruzada entre los miembros de la tripulación, para asegurar el inmediato y correcto cumplimiento de las autorizaciones del ATC;

c) uso y limitaciones de precisión de los altímetros de reserva en casos de contingencia. De ser el caso, el piloto debería revisar la aplicación de la corrección de error de la fuente estática (SSEC) y la corrección de error de posición (PEC) mediante el uso de tarjetas de corrección;

d) problemas de percepción visual en el avistamiento de otras aeronaves a una distancia de 300 m (1000 ft) de separación vertical bajo condiciones nocturnas, ante la presencia de luces septentrionales, para el tránsito en direcciones opuestas y en la misma dirección, y durante giros;

e) características de los sistemas de detección de altitud de la aeronave que pudieran dar lugar (overshoots);

f) relación entre altimetría, control automático de altitud y sistemas de transpondedor bajo condiciones normales y anormales; y

g) restricciones operacionales de las aeronaves (en caso de ser requeridas para el grupo específico de aeronaves) relacionadas con la aprobación de aeronavegabilidad.

5.6 Manuales y listas de verificación de operaciones

5.6.1 Se debería modificar los manuales y listas de verificación apropiados de manera que incluyan información y/u orientación sobre los procedimientos de operación normalizados y las limitaciones de error altimétrico para las verificaciones en tierra. Los manuales y listas de verificación apropiados deberían ser presentados a las autoridades para su revisión, como parte del proceso de solicitud.

PARTE 6 – PROCEDIMIENTOS ATC

6.1 Generalidades

6.1.1 La implantación de la RVSM exige:

a) una mayor vigilancia con respecto a:

i) la emisión de autorizaciones a las aeronaves; y

ii) la verificación de la debida comprensión y cumplimiento de las autorizaciones por parte de las tripulaciones de vuelo;

b) la adopción de medidas para enfrentar una potencial concentración de tránsito; y

c) informar a los controladores acerca de sus responsabilidades en cuanto a las acciones a ser adoptadas:

i) cuando se planifica vuelos de aeronaves que se sabe carecen del equipo necesario para efectuar vuelos en espacio aéreo RVSM;

ii) cuando reciben información que una aeronave ha perdido la capacidad de mantener un CFL apropiado a los requisitos RVSM;

iii) cuando el piloto solicita información de tránsito para ayudar a aliviar posibles problemas de percepción visual;

iv) para salvaguardar la separación entre aeronaves cuando el piloto notifica que la capacidad del AKD ha caído por debajo de lo requerido para un espacio aéreo RVSM; y

v) cuando exista una diferencia de 300 ft ó más entre la altitud indicada y el CFL.

6.2 Operaciones militares

6.2.1 Se recuerda a los Estados la responsabilidad reconocida que tienen respecto al tránsito militar, como se especifica en los *Procedimientos para los servicios de navegación aérea/Gestión del Tránsito Aéreo* (PANS-ATM, Doc 4444), Parte II, Sección 6. Al respecto, debe elaborarse procedimientos relativos a las operaciones aéreas militares que no satisfacen los requisitos mencionados en la Parte 3 de este documento en relación a los equipos. En dichos procedimientos, se debe especificar la manera en que las operaciones aéreas militares que no cumplen con los requisitos RVSM se deberán efectuar en dicho espacio aéreo, separándolas del tránsito aéreo que cuenta con una VSM de 1000 ft por encima del FL 290. Entre los métodos de operación aplicables, figuran:

a) reservas provisionales de espacio aéreo;

b) altitudes por bloques;

c) rutas especiales exclusivas para aeronaves militares; y

d) rutas especiales para aeronaves militares que requieran una VSM de 2000 ft por encima del FL 290.

6.3 Confirmación de la situación de aprobación

6.3.1 Una responsabilidad secundaria de las autoridades ATS consiste en establecer verificaciones de rutina de la situación de aprobación de las aeronaves que pretenden operar en espacio aéreo RVSM. Esta responsabilidad se satisface de la siguiente manera:

a) examinando a fondo los planes de vuelo ATS;

b) reteniendo las autorizaciones ATC para las operaciones que no cumplen con los requisitos del espacio aéreo.

6.3.1.1 Los proveedores de ATS que estén en condiciones de hacerlo pueden también ampliar la verificación de manera que incluya:

a) verificaciones cruzadas con la base de datos central; y

b) el cuestionamiento de los explotadores que no cumplen con los requisitos del espacio aéreo.

6.4 Vigilancia táctica del espacio aéreo RVSM Excluyente

6.4.1 El controlador deberá verificar la situación de la aprobación RVSM de la aeronave si el piloto solicita operar en espacio aéreo RVSM y el sufijo del equipo de a bordo no indica que la aeronave esté aprobada. Si el piloto no confirma que la aeronave cuenta con la aprobación del Estado, entonces, salvo en una situación de emergencia, el controlador no emitirá una autorización para operar en espacio aéreo RVSM.

6.4.2 Los proveedores de ATS deberán brindar información a la CARSAMMA sobre los vuelos que no se realizan en espacio aéreo RVSM.

PARTE 7 – PROCEDIMIENTOS DE CONTINGENCIA PARA PILOTOS Y CONTROLADORES

7.1 Objectivo

7.1.1 El siguiente material tiene por objeto brindar orientación al piloto y al controlador de tránsito aéreo en cuanto a las acciones a ser adoptadas bajo ciertas condiciones de falla de equipo y de turbulencia. Se reconoce que el piloto y el controlador utilizarán su criterio para determinar las acciones más apropiadas en una determinada situación. El material de orientación reconoce que, para ciertas fallas de equipo, el curso de acción más seguro podría ser que la aeronave continúe en espacio aéreo RVSM mientras el piloto y el controlador adoptan medidas cautelares para proteger la separación. Sin embargo, para los casos extremos de fallas de equipo, el curso de acción más seguro podría ser que la aeronave abandone el espacio aéreo RVSM, obteniendo una autorización revisada del ATC o, si no puede obtener la autorización previa del ATC, ejecutando la maniobra de contingencia especificada en los Procedimientos Suplementarios Regionales (Doc 7030 de la OACI) para abandonar la ruta o derrota asignada. Se ha desarrollado procedimientos de desviación de derrota para su publicación en el Doc 7030 de la OACI. Estos procedimientos son únicamente aplicables a las aeronaves que operan en un sistema organizado de derrotas (OTS).

7.1.2 Además de las condiciones de emergencia que requieren un descenso inmediato, como la pérdida de empuje o de presurización, se deberá informar al ATC acerca de las condiciones menos explícitas que hacen imposible que una aeronave mantenga su CFL mientras se encuentra en espacio aéreo RVSM. Los controladores deben reaccionar ante tales condiciones, pero no se puede especificar cuáles deben ser estas acciones, ya que dependerán de las condiciones dinámicas del momento.

7.2 Responsabilidad del piloto al mando

7.2.1 De ninguna manera deberá entenderse que la siguiente orientación sobre procedimientos de contingencia menoscaba la autoridad y la responsabilidad que, en última instancia, tiene el piloto al mando por la segura operación de la aeronave.

7.3 Falla de los AKD automáticos (*e.g.*, mantenimiento de altitud en piloto automático)

	El piloto debería	El controlador debería
Inicialmente	mantener el CFL y evaluar la capacidad de la aeronave de mantener la altitud mediante control manual	
Posteriormente	estar alerta al tráfico en conflicto, tanto visualmente como a través del ACAS, en caso de contar con dicho equipo si lo considera necesario, alertar a las aeronaves cercanas, utilizando al máximo las luces exteriores y difundiendo su posición, nivel de vuelo e intenciones en los 121.5 MHz (como respaldo, se puede utilizar la frecuencia VHF aire-aire entre pilotos) notificar al ATC acerca de la falla utilizando la frase "RVSM IMPOSIBLE DEBIDO EQUIPO", así como del curso de acción que pretende adoptar. Entre los posibles cursos de acción, figuran: mantener el CFL, siempre y cuando la aeronave pueda mantener el nivel; solicitar autorización al ATC para ascender por encima o descender por debajo del espacio aéreo RVSM, en caso que la aeronave no pueda mantener el CFL, y el ATC no pueda establecer una separación lateral, longitudinal o vertical convencional; o ejecutar la maniobra de contingencia del Doc 7030 para desviarse de la derrota y altitud asignadas si no puede obtener la autorización del ATC y la aeronave no puede	averiguar la intención del piloto y transmitir información esencial sobre el tránsito si el piloto tiene intenciones de continuar en espacio aéreo RVSM, evaluar la situación del tránsito para determinar si se puede dar cabida a la aeronave brindando separación lateral, longitudinal o vertical convencional y, en ese caso, aplicar la separación mínima apropiada si el piloto solicita autorización para salir del espacio aéreo RVSM, darle las facilidades de inmediato, de ser posible si no se puede establecer una separación adecuada y no es posible satisfacer la solicitud del piloto de autorizarlo a salir del espacio aéreo RVSM, proporcionar al piloto información esencial sobre el tránsito, notificar a las otras aeronaves cercanas y continuar

	mantener el CFL	vigilando la situación notificar a las instalaciones/sectores ATC adyacentes acerca de la situación

7.4 Pérdida de redundancia de los sistemas altimétricos primarios, si el sistema altimétrico restante funciona normalmente

El piloto debería	**El controlador debería**
Si el sistema altimétrico restante funciona normalmente, acoplar dicho sistema al sistema automático de control de altitud, notificar al ATC acerca de la pérdida de redundancia y mantenerse alerta al mantenimiento de la altitud	reconocer la situación y continuar vigilando su desarrollo

7.5 Todos los sistemas altimétricos primarios fallan, o no son considerados confiables

El piloto debería	El controlador debería
mantener el CFL, tomando como referencia el altímetro de reserva (si la aeronave cuenta con dicho equipo)	
alertar a las aeronaves cercanas, utilizando al máximo las luces exteriores y difundiendo su posición, nivel de vuelo e intenciones en los 121.5 MHz (como respaldo, se puede utilizar la frecuencia VHF aire-aire entre pilotos)	
considerar declarar una emergencia. Notificar al ATC acerca de la falla y del curso de acción que pretende tomar, utilizando la frase "RVSM IMPOSIBLE DEBIDO EQUIPO". Entre los posibles cursos de acción, figuran:	evaluar la situación del tránsito a fin de determinar si se puede acomodar a la aeronave brindando separación lateral, longitudinal o vertical convencional y, de ser así, aplicar la separación mínima apropiada
mantener el CFL y la ruta, siempre y cuando el ATC pueda proporcionar la separación lateral, longitudinal o vertical convencional	si no se puede brindar la separación, proporcionar al piloto información esencial sobre el tránsito, y preguntarle acerca de sus intenciones
solicitar al ATC autorización para ascender por encima o descender por debajo del espacio aéreo RVSM, si el ATC no puede establecer una separación adecuada con las otras aeronaves	si el piloto solicita autorización para salir del espacio aéreo RVSM, darle las facilidades de inmediato, de ser posible en caso de no poder dar la autorización para que la aeronave salga del espacio aéreo, proporcionar al piloto información sobre el tránsito, alertar a las aeronaves cercanas y vigilar la situación
ejecutar la maniobra de contingencia del Doc 7030 para desviarse de la derrota y altitud asignadas si no puede obtener la autorización del ATC	notificar a las instalaciones/sectores ATC adyacentes acerca de la situación

7.6 Los altímetros primarios difieren en más de 200 ft

El piloto debería
tratar de identificar el sistema defectuoso mediante los procedimientos establecidos para la detección de fallas y/o comparando las lecturas del altímetro primario con el altímetro de reserva (corregidas con las tarjetas de corrección, de ser necesario)
si se puede identificar el sistema defectuoso, acoplar el sistema altimétrico que está operativo al AKD y proceder según 7.4 arriba
si no se puede identificar el sistema defectuoso, seguir las indicaciones del párrafo 7.5 arriba en relación a la falla o lecturas no confiables en todos los altímetros primarios.

7.7 Turbulencia (más que moderada) que, en opinión del piloto, afectará la capacidad de la aeronave de mantener el CFL

El piloto debería	El controlador debería
estar alerta al tránsito en conflicto, tanto visualmente como a través del ACAS, en caso de contar con dicho equipo	
alertar a las aeronaves cercanas, utilizando al máximo las luces exteriores y difundiendo su distintivo de llamada, posición, nivel de vuelo, naturaleza y severidad de la turbulencia e intenciones en los 121.5 MHz (como respaldo, se puede utilizar la frecuencia VHF aire-aire entre pilotos)	
notificar al ATC acerca del curso de acción que pretende adoptar. Entre los posibles cursos de acción, figuran: mantener el CFL y la ruta, siempre y cuando el ATC pueda proporcionar separación lateral, longitudinal o vertical convencional de ser necesario, solicitar cambio de nivel de vuelo ejecutar la maniobra de contingencia del Doc 7030 para abandonar la derrota y nivel de vuelo asignados si no puede obtener la autorización del ATC y la aeronave no puede mantener el CFL	evaluar la situación del tránsito a fin de determinar si puede acomodar a la aeronave brindando separación lateral, longitudinal o mayor separación vertical y, de ser así, aplicar la separación mínima apropiada si no se puede brindar la separación, proporcionar al piloto información esencial sobre el tránsito, preguntarle acerca de sus intenciones, notificar a las otras aeronaves cercanas y vigilar la situación notificar a las instalaciones/sectores ATC adyacentes acerca de la situación ***Nota: En base a esta información, el proveedor ATS debería considerar la suspensión de las operaciones RVSM***

7.8 Falla del transpondedor

El piloto debería	El controlador debería
notificar al ATC antes de ingresar a un espacio aéreo donde normalmente se requiere un transpondedor	adoptar las acciones establecidas por el Estado proveedor.

7.9 Condiciones meteorológicas

7.9.1 Las condiciones meteorológicas pueden causar turbulencia que puede perjudicar la precisión de mantenimiento de altitud. Si una aeronave informa acerca de turbulencia más que moderada y se encuentra dentro de un rango de 5 minutos de otra aeronave con una separación vertical de 1000 ft, el ATC tratará de establecer una separación de 2000 ft, haciendo que una de las dos aeronaves ascienda o descienda.

7.9.2 Cabe señalar que cualquier instalación ATC puede solicitar un aumento de la separación mínima como resultado de condiciones meteorológicas adversas, lo cual podría resultar en la suspensión temporal de la RVSM en áreas escogidas del espacio aéreo RVSM.

PARTE 8 - VIGILANCIA DE LA PERFORMANCE DEL SISTEMA

8.1 Generalidades

8.1.1 El siguiente material tiene como objeto brindar orientación sobre la vigilancia de la operación de la RVSM en las Regiones del Caribe y Sudamérica. La vigilancia 1) garantizará que el nivel del riesgo de colisión no exceda el TLS regional, y 2) permitirá evaluar el cumplimiento de la especificación de performance global de mantenimiento de altitud por parte de las aeronaves (ver la sección 2.2). La información recolectada por la agencia de monitoreo será uno de los factores que los encargados de tomar decisiones tomarán en cuenta al momento de determinar si se están alcanzando las metas generales de seguridad operacional aplicables al espacio aéreo RVSM del Caribe y Sudamérica.

8.1.2 El criterio de seguridad operacional en las Regiones del Caribe y Sudamérica es que se debe cumplir con el TLS de cinco accidentes fatales en 10^9 horas de vuelo (que representa el riesgo debido a la pérdida de separación vertical por cualquier causa).

8.1.3 Los errores de mantenimiento de altitud que generan riesgo de colisión pueden dividirse en dos categorías: errores técnicos y desviaciones importantes de altitud. Los errores técnicos se deben a imprecisiones en el equipo de mantenimiento de altitud de la aeronave: ASE y FTE. Las desviaciones importantes de altitud se deben a:

a) errores operacionales (la aeronave se encuentra a un nivel de vuelo que no es el asignado, debido a errores en el bucle ATC-piloto y a autorizaciones incorrectas);

b) eventos de contingencia de la aeronave que ocurren en situaciones en que el piloto, en un inicio, no puede seguir los procedimientos de contingencia normales y se ve forzado a descender a través de niveles de vuelo antes de desviarse de la derrota;

c) condiciones meteorológicas a grandes alturas, y

d) avisos de resolución del TCAS.

8.1.4 A menudo, las aeronaves en el espacio aéreo del Caribe y Sudamérica son controladas mediante la aplicación de una separación de procedimiento, estando la vigilancia por parte del ATC restringida a los informes de posición del piloto en los puntos de recorrido. En consecuencia, las desviaciones importantes de altitud contribuyen al riesgo de colisión total en forma más significativa que en un ambiente con vigilancia radar. Se ha elegido un TLS que toma en cuenta el riesgo proveniente tanto de los errores técnicos como de las desviaciones importantes de altitud.

8.1.5 A fin de asegurar que no se exceda el TLS, es necesario vigilar, inicialmente, tanto la ocurrencia de errores verticales como ciertos valores de los parámetros del CRM; otros parámetros del CRM deberían ser vigilados constantemente. Muchos de los valores de los parámetros utilizados en el CRM están basados en un horizonte de planificación de aproximadamente 10 años, y requieren una vigilancia periódica.

8.1.6 Los parámetros del CRM pertenecen a dos grupos, desde el punto de vista de los requisitos de vigilancia. El primer grupo comprende tres parámetros que son críticos para la evaluación de la seguridad operacional, en el sentido que el riesgo real en el espacio aéreo varía en proporción a las variaciones en sus valores. El primer parámetro es la proporción de tiempo que las aeronaves están nominalmente separadas por 1000 ft en superposición vertical y es una medida de la performance de mantenimiento de altitud de la población total de aeronaves. Se denomina "probabilidad de superposición vertical" y se representa como $P_z(1000)$. El segundo es una medida del número de encuentros de aeronaves por hora de vuelo, y se denomina "frecuencia de encuentro". El tercero es una medida de la performance de mantenimiento de altitud, denominado "probabilidad de superposición lateral" y que se representa como $P_y(0)$.

8.1.7 El segundo grupo de parámetros del CRM es menos exigente, ya sea porque el CRM es relativamente insensible a sus valores, o porque no se espera que cambien sustancialmente a lo largo del horizonte de planificación de este documento. Luego de su evaluación inicial, deberían ser reevaluados periódicamente, a fin de verificar que sus valores reflejan el sistema de espacio aéreo RVSM vigente.

8.1.8 Cabe resaltar que los requisitos de vigilancia, especialmente la medición del TVE, fueron establecidos a un nivel riguroso que resultaba apropiado para una aplicación inicial en la primera región donde se implantó la RVSM. Como resultado de ese trabajo inicial y en base a los datos recolectados y a la experiencia operacional adquirida, es posible aplicar requisitos de vigilancia algo menos rigurosos en otras regiones donde se introduce la RVSM como parte de un proceso de implantación mundial. Por ejemplo, algunos de los explotadores y tipos de aeronaves que utilizan el espacio aéreo RVSM en las Regiones NAT, EUR y Asia/PAC también operan en las Regiones del Caribe y Sudamérica. Los requisitos de vigilancia para estos explotadores deberían reducirse considerablemente.

8.1.9 Es importante recordar que todas las medidas que, en conjunto, constituyen o sirven para verificar la performance de mantenimiento de altitud de una aeronave desempeñan un papel dentro del concepto de vigilancia que se aplicará a lo largo de la vida de la aeronave y contribuyen a reducir el riesgo. Las medidas incluyen:

a) el requisito de que la aeronave esté equipada de acuerdo a lo establecido en la MASPS RVSM;

b) los procedimientos iniciales de instalación, las pruebas y, en caso necesario, las verificaciones en vuelo del equipo altimétrico de la aeronave;

c) el cumplimiento de los procedimientos de aprobación de aeronavegabilidad por parte del Estado;

d) el cumplimiento de los requisitos de mantenimiento de la aeronavegabilidad;

e) el cumplimiento de los procedimientos ATC; y

f) el cumplimiento de los procedimientos operacionales previos al vuelo y en vuelo.

8.1.10 Todas las medidas arriba indicadas han sido abordadas en las partes pertinentes de este material de orientación. No obstante, estas medidas no constituyen una indicación directa del cumplimiento del criterio general de seguridad operacional. Esto se puede lograr, únicamente, mediante una vigilancia independiente de la performance del sistema.

8.2 Modelo de riesgo de colisión (CRM)

8.2.1 El método utilizado para evaluar el riesgo de colisión del sistema en las Regiones del Caribe y Sudamérica será el mismo al utilizado en la determinación original de la factibilidad de la RVSM, el CRM de Reich. Este modelo combina factores del sistema operacional, mediante elementos probabilísticos y determinísticos, para generar un estimado del riesgo promedio de colisión a largo plazo de las aeronaves en el sistema. Para la dimensión vertical, el enunciado del modelo se divide en seis partes. La parte 1 se aplica al nivel de vuelo; la parte 2 se aplica a las aeronaves que descienden atravesando distintos niveles de vuelo; la parte 3 se aplica a las aeronaves que utilizan un nivel de vuelo incorrecto; la parte 4 se aplica a las rutas convergentes; la parte 5 se aplica a los vuelos en formación; y la parte 6 se aplica a las aeronaves alineadas verticalmente durante todo el cruce a niveles de vuelo adyacentes. Cada una de las 6 partes del modelo de riesgo de colisión para la dimensión vertical aparecen en el Apéndice B.

8.3 Vigilancia y evaluación de los parámetros de la especificación del CRM

8.3.1 A fin de garantizar que el riesgo de colisión en las operaciones RVSM de las Regiones del Caribe y Sudamérica no exceda el TLS regional, los parámetros del CRM deben ser vigilados y evaluados en forma constante.

8.4 Errores técnicos de vigilancia y desviaciones importantes de altitud para evaluar la $P_z(1000)$

8.4.1 El TLS de 5.0×10^{-9} accidentes fatales por hora de vuelo para operaciones RVSM acordado para las Regiones del Caribe y Sudamérica exige una evaluación de la probabilidad de superposición vertical ($P_z(1000)$) del sistema total. Para ello, se deberá notificar y evaluar la duración de todos los errores importantes en el plano vertical. Además de los errores técnicos detectados mediante el sistema de vigilancia de altitud (es decir, el TVE, ASE y AAD), también es necesario informar acerca de las desviaciones importantes de altitud.

8.4.2 La evaluación del TVE es esencial para evaluar la $P_z(1000)$. Por consiguiente, la precisión con la que se mida el TVE constituye una preocupación importante. Se puede medir el TVE comparando la altitud geométrica de la aeronave, medida a través de un HMU o GMS o cualquier otro sistema apropiado, con la altitud geométrica de su nivel de vuelo asignado, medida a través de un modelo meteorológico apropiado. La precisión de la medición del TVE deber ser tal que el error medio sea 0 ft y la desviación característica del error no exceda 50 ft.

8.4.3 Estos datos medidos del TVE son fundamentales para el proceso de vigilancia. Se requiere grandes cantidades de estos datos TVE para obtener inferencias del proceso de vigilancia con un alto nivel de confianza. La Parte 2 de este documento describe un proceso para apoyar la introducción de la RVSM en las Regiones del Caribe y Sudamérica en base a los datos de vigilancia.

8.4.4 Las desviaciones importantes de altitud pueden dividirse en cuatro tipos principales:

a) errores operacionales (errores de bucle ATC-piloto y autorizaciones incorrectas);

b) contingencias relacionadas con la aeronave;

c) desviaciones ocasionadas por efectos meteorológicos; y

d) desviaciones ocasionadas por avisos de resolución del TCAS

8.4.5 Es probable que los errores operacionales harán que las aeronaves vuelen a múltiplos enteros de la norma de separación con respecto a su nivel correcto. Debido a los prolongados intervalos entre informes de posición y a los métodos de comunicación utilizados, los errores operacionales contribuyen al riesgo de colisión total mucho más que en un espacio aéreo con un control de tránsito aéreo basado en la vigilancia radar y en sistemas de comunicaciones directas. Los cálculos basados en las ocurrencias de errores verticales importantes de ese tipo reportados en la Región NAT indican que éstos son los que más contribuyen al riesgo de colisión. Por lo tanto, es muy importante calcular la contribución que hacen estos tipos de errores a la probabilidad de superposición vertical. La información sobre estos tipos de eventos se obtiene a través de los informes del ATC y del piloto. Es vital que las notificaciones de todos los errores operacionales sean enviadas por los Estados proveedores a la agencia regional de monitoreo.

8.4.6 El riesgo del sistema es directamente proporcional al total del tiempo de vuelo de la aeronave en un nivel de vuelo incorrecto. El cálculo de tales eventos será uno de los elementos clave para determinar si el sistema cumple o no con el TLS, utilizando los métodos matemáticos y estadísticos apropiados.

8.4.7 Las fuentes de datos para calcular el tiempo que las aeronaves pasan en un nivel de vuelo incorrecto incluirán los informes enviados por las autoridades ATC y las aerolíneas a la agencia regional de monitoreo, así como los resultados de ejercicios especiales de recolección de datos en que se utilicen sistemas de vigilancia apropiados.

8.4.8 Las contingencias podrían representar un riesgo especialmente importante en espacio aéreo oceánico debido a la falta de vigilancia y al uso de comunicaciones indirectas. Los procedimientos de contingencia están diseñados para reducir estos riesgos al mínimo, pero es importante incluirlos en el análisis general. Si se sigue los procedimientos arriba indicados, el riesgo de colisión con otra aeronave debería quedar reducido a un mínimo en la mayoría de los casos. No obstante, es posible que la naturaleza de la emergencia sea tal que la aeronave se vea obligada a descender a través de uno o más niveles antes de poder desviarse de su derrota original. Es este descenso a través de niveles potencialmente ocupados lo que más contribuye al riesgo de colisión. Para poder evaluar el riesgo, el informe de contingencias que se exige de los pilotos debería incluir la cantidad de niveles transitados antes de empezar a desviarse de la derrota.

8.4.9 Las desviaciones meteorológicas incluyen los efectos de la turbulencia de aire y también podrían incluir eventos más inusuales tales como los efectos de las nubes de polvo volcánico. Esta categoría sólo incluye las desviaciones involuntarias ocasionadas por condiciones externas; los efectos de las desviaciones resultantes del evitamiento deliberado de condiciones meteorológicas adversas, etc., pueden ser determinados de la misma manera que para las contingencias.

8.4.10 Cuando una aeronave ingresa a aire turbulento, como el que existe dentro de los sistemas de tormentas, su capacidad de mantenimiento de altitud puede deteriorarse considerablemente. Esto puede generar desviaciones con respecto al nivel de presión correcto, que, en algunos casos, pueden ser de más de 1000 ft. Obviamente, este tipo de desviación puede aumentar el riesgo de colisión y la magnitud del riesgo será mayor si las normas de separación son menores. Será necesario vigilar y examinar continuamente la incidencia de las desviaciones causadas por turbulencia, a fin de asegurar que el riesgo asociado con tales eventos no sea excesivo.

8.4.11 El TCAS es un sistema anticolisión de a bordo exigido por algunos Estados para las aeronaves comerciales de gran tamaño. Por consiguiente, un alto porcentaje de aeronaves que operan en las Regiones del Caribe y Sudamérica está equipado con TCAS. El TCAS puede proporcionar avisos de tránsito (TA) y avisos de resolución (RA) cuando existe una separación normalizada en un ambiente RVSM. Es neceasrio evaluar la cantidad exacta y tipo de los TA y RA.

8.4.12 Si la magnitud de la desviación de altitud es significativa, es importante incluir el evento que da lugar a un RA del TCAS en el proceso de riesgo de colisión. En el espacio aéreo RVSM de las Regiones del Caribe y Sudamérica, el TCAS sólo emitirá RA auténticos como resultado de una de las categorías de desviación de altitud ya descritas (o como resultado de una desviación lateral). Por otro lado, los RA leves generalmente solicitarán al piloto que regrese la aeronave a su nivel original. Normalmente, los RA del TCAS no añadirán un riesgo “no justificado” al sistema, aunque, muy ocasionalmente, el TCAS puede ocasionar una pérdida de separación como resultado de un RA inapropiado. Por lo tanto, será necesario considerar cada evento del TCAS en forma individual.

8.5 Vigilancia de la $P_z(1000)$

8.5.1 Existen dos métodos para calcular la $P_z(1000)$. En el primer método, se deriva una función de densidad de probabilidad analítica directamente de la proporción de TVEs de una magnitud dada, mediante modelos de distribución estadística, la cual es luego utilizada para derivar un estimado de la $P_z(1000)$. El segundo método consta de dos partes. En la primera parte, de la proporción de ASEs de una determinada magnitud, se deriva funciones de densidad de probabilidad analítica para cada tipo de aeronave, y luego se vuelven a combinar en las proporciones que se encuentran estos tipos de aeronaves en vuelo horizontal dentro del espacio aéreo del Caribe y Sudamérica. En la segunda parte, de los datos de la AAD y de las desviaciones importantes de altitud que no involucran desviaciones de aeronaves en niveles de vuelo incorrectos, se deriva funciones de densidad de probabilidad analítica. Luego, se combina numéricamente el modelo de distribución estadística del conjunto de ASEs con la función de densidad de probabilidad analítica de los datos de la AAD y las desviaciones importantes de altitud para generar una distribución estadística del TVE, la cual se utiliza luego para derivar un estimado de la $P_z(1000)$. La ventaja del primer método es que utiliza directamente los datos del TVE obtenidos de la vigilancia. La ventaja del segundo método es que elimina parte del sesgo de muestreo que podría ser introducido por el proceso de vigilancia, y que utiliza fuentes de desviaciones importantes de altitud que están fuera de las zonas de cobertura de la vigilancia de altitud.

8.6 Pronóstico de ocupación (frecuencia de encuentros) de aeronaves RVSM previa a la implantación de la RVSM

8.6.1 Una vez implantada la RVSM, se obtendrá valores estimados de la ocupación o frecuencia de encuentros, en base a un programa de muestreo de las operaciones vigentes. No obstante, durante la Fase de Verificación, se necesita un método para pronosticar la ocupación (o frecuencia de encuentros) en un ambiente con una VSM de 1000 ft, a fin de evaluar el riesgo de colisión esperado en un ambiente RVSM.

8.6.2 Los análisis de la RVSM para la Región NAT fueron realizados en base a un Modelo computarizado de Asignación de Tránsito para la Región NAT (NATTAM). Se necesita una simulación comutarizada de este tipo, desarrollada por Canadá, para predecir la futura ocupación a ser utilizada en la evaluación del riesgo de colisión previo a la implantación de la RVSM en las Regiones del Caribe y Sudamérica. A fin de brindar información de referencia y evaluar el alcance y capacidad del modelo de simulación que se necesita para las Regiones del Caribe y Sudamérica, el Apéndice C presenta una breve descripción del NATTAM. Las capacidades del modelo de simulación para las Regiones del Caribe y Sudamérica deberían incluir:

a) la asignación de rutas, niveles de vuelo y horarios de vuelo;

b) los volúmenes y patrones de tránsito;

c) la estructura del espacio aéreo y del sistema de derrotas;

d) concentración del tránsito hacia las derrotas y niveles de vuelo preferidos por los explotadores de aeronaves; y

e) cálculo de la ocupación vertical y la frecuencia de encuentros.

8.6.3 Otra fuente de datos para el modelo de simulación que podría ser utilizada para perfeccionar la asignación de vuelos, la concentración hacia las derrotas principales y la resolución de conflictos podría ser el análisis de los cambios ocurridos en la Región NAT antes y después de la implantación de la RVSM.

8.6.7 Además de las capacidades de la simulación de la Región NAT, la simulación de las Regiones del Caribe y Sudamérica deberá poder pronosticar la frecuencia de cruce de derrotas en el ambiente RVSM.

8.7 Vigilancia de la frecuencia de encuentro de aeronaves luego de la implantación de la RVSM

8.7.1 La frecuencia de encuentro de aeronaves que vuelan en el mismo sentido, en sentidos opuestos o en derrotas convergentes en las Regiones del Caribe y Sudamérica será evaluada mensualmente por la agencia regional de monitoreo, utilizando datos del tráfico proporcionados por las autoridades ATC. Debido a que las Regiones del Caribe y Sudamérica tienen un mayor nivel de tráfico en rutas convergentes, es necesario evaluar la frecuencia de cruce de derrotas en las intersecciones de ruta. Se prevé que el nivel de frecuencia de encuentros seguirá siendo consideramente inferior al utilizado para derivar la performance de mantenimiento de altitud de la aeronave en la especificación de performance del sistema global.

8.8 Vigilancia de la probabilidad de superposición lateral

8.8.1 La probabilidad de superposición lateral ($P_y(0)$) es la probabilidad que tienen dos aeronaves que nominalmente se hallan en la misma derrota de hallarse a una distancia lateral no mayor de (la envergadura promedio de las aeronaves) entre sí. El valor de este parámetro depende de la precisión de navegación lateral y envergadura de las aeronaves en la región. Cuanto mayor la precisión de navegación o la envergadura, mayor será la probabilidad de superposición lateral. Para los cálculos del riesgo de colisión vertical, se utiliza los errores de las aeronaves *que ingresan* al océano para determinar $P_y(0)$. Se espera que la desviación característica en estos errores sea menor que la observada en los errores de aeronaves *que salen* de la Región Asia/Pacífico, pero su utilización garantiza que el riesgo de colisión vertical promedio no será subestimado. La forma de la distribución utilizada para modelar la performance de navegación en la región principal también afecta el valor de $P_y(0)$.

8.8.2 Debido a que una mejor precisión de mantenimiento de la trayectoria lateral, si todos los otros factores permanecen constantes, aumenta el riesgo de colisión resultante de la pérdida de una separación vertical de 1000 ft, la agencia regional de monitoreo examinará periódicamente los errores de cruce de derrotas en el espacio aéreo, en base a los datos proporcionados por las autoridades ATS. La especificación de performance global de mantenimiento de altitud para el TVE fue desarrollada asumiendo una precisión de navegación lateral con una desviación característica de 0.3 NM. Las autoridades deberían reconocer que los cambios en la precisión de mantenimiento de la trayectoria lateral de las aeronaves tienen un efecto directo sobre el CRM y deberían efectuar revisiones periódicas para evaluar los efectos que podrían tener cambios obligatorios o de otra índole en el equipo de navegación de la aeronave.

8.9 Vigilancia de los demás parámetros del CRM

8.9.1 Los demás parámetros del CRM en el espacio aéreo RVSM de las Regiones del Caribe y Sudamérica son la velocidad promedio de las aeronaves, la velocidad relativa entre aeronaves y la longitud, ancho y altura promedio de las aeronaves. Como se ha mencionado anteriormente, o el riesgo de colisión en vuelo es relativamente insensible a los valores de estos parámetros, o no se prevé que los valores cambien de manera significativa en el horizonte de planificación del presente documento. La vigilancia intensiva de los valores de los citados parámetros no debería ser necesaria una vez calculados inicialmente. La agencia regional de monitoreo debería estar consciente de la importancia relativa de los mismos en el proceso global destinado a asegurar el mantenimiento de la seguridad operacional del sistema y evaluar periódicamente sus valores probables, utilizando todos los medios que se consideren apropiados.

8.9.2 Todos los parámetros relacionados con las características físicas de las aeronaves pueden ser calculados en base a observaciones directas del sistema. Las dimensiones de las aeronaves ($\lambda_x, \lambda_y, \lambda_z$) se obtienen utilizando la envergadura, longitud y altura de los distintos tipos de aeronave. Luego, se calcula los valores medios para la población de aeronaves en las Regiones del Caribe y Sudamérica, utilizando ponderaciones basadas en la frecuencia de encuentros realizados por cada uno de los tipos.

8.9.3 La velocidad aerodinámica absoluta promedio de la aeronave ($\overline{|V|}$) se obtiene utilizando las velocidades autorizadas de las aeronaves que operan en la región. La precisión de este cálculo está determinada por el tamaño de la muestra utilizada. Para calcular la velocidad relativa absoluta promedio paralela a la derrota ($\overline{|\Delta V|}$), se utiliza datos sobre pares de aeronaves en niveles adyacentes. Como ocurre con la velocidad aerodinámica promedio, la precisión de este cálculo depende del tamaño de la muestra.

8.9.4 La velocidad relativa absoluta promedio perpendicular a la derrota ($\overline{|\dot{y}|}$) se evalúa utilizando los datos radar sobre las aeronaves que salen del sistema del Caribe y Sudamérica. Se espera que este parámetro se mantenga bastante estable con el transcurso del tiempo, cambiando sólo gradualmente con la introducción de nuevos sistemas de navegación con una performance significativamente mejor.

8.9.5 En teoría, se debería determinar la velocidad vertical relativa absoluta promedio ($\overline{|\dot{z}|}$) para pares de aeronaves que han perdido toda separación vertical. En la práctica, es improbable que se observe una pérdida total de separación vertical. Por lo tanto, el valor se calcula indirectamente en base a mediciones radar de la precisión de las velocidades relativas para pares de aeronaves con distintas desviaciones, y haciendo la extrapolación con respecto a la norma de separación vigente.

8.9.7 Actualmente, la determinación de los otros parámetros λ_{xz} (igual) y λ_{xz} (opuesto) para la longitud de la trayectoria en el modelo de riesgo de colisión para aeronaves en descenso deberá hacerse mediante simulación para las aeronaves de las Regiones del Caribe y Sudamérica.

8.10 Vigilancia y evaluación del cumplimiento de la performance del sistema

8.10.1 Una vez monitoreados los parámetros del CRM, se puede evaluar el sistema para determinar si cumple con las restricciones impuestas por los requisitos de performance ya sean globales o regionales. Es importante recordar la diferencia entre los requisitos de performance del sistema global y regional. Los requisitos de performance del sistema global se aplican únicamente al mantenimiento de altitud de las aeronaves y están diseñados para su aplicación a nivel mundial. En tal sentido, las restricciones en materia de mantenimiento de altitud y perfomance lateral de las aeronaves están diseñadas para ser más rigurosas que las requeridas para el cumplimiento a nivel regional, mientras que las restricciones globales con respecto a los valores de ocupación se supone serán menos rigurosas que los valores regionales (dando cabida a la amplia gama de ocupaciones regionales previstas a nivel mundial).

8.10.2 Los requisitos de performance del sistema regional se aplican a las desviaciones verticales resultantes de todas las causas. No obstante, se espera que los requisitos regionales oceánicos de mantenimiento de altitud serán menos severos que los requisitos globales, ya que 1) las ocupaciones pueden ser muy inferiores a los valores utilizados para derivar los requisitos globales (como se prevé dentro del espacio aéreo oceánico) y 2) la performance lateral no alcanza los niveles de diseño utilizados para los requisitos globales.

8.11 Performance del sistema regional

8.11.1 El cumplimiento del TLS regional se determina desde dos puntos de vista. Una perspectiva se obtiene calculando directamente el riesgo del sistema, reemplazando cada uno de los cálculos de los parámetros en las ecuaciones de riesgo de colisión que aparecen en el

Apéndice B. La aplicación de esta perspectiva generará un solo valor estimado del riesgo de colisión, y ofrece una medida que puede ser comparada con el TLS. Sin embargo, está sujeta a la incertidumbre impuesta por cada uno de los cálculos de los parámetros.

8.11.2 Otra perspectiva se obtiene evaluando si se está cumpliendo con el TLS en forma altamente confiable en términos estadísticos. Esta perspectiva se puede usar para pronosticar si se cumplirá con el TLS en un ambiente RVSM o para determinar si se está cumpliendo con el TLS una vez implantada la RVSM. Esta perspectiva no requiere un estimado del parámetro $P_z(1000)$ del CRM. Sin embargo, depende de la confirmación de que la MASPS --la cual está diseñada para generar un riesgo insignificante debido al ASE para las aeronaves aprobadas para operar en un ambiente RVSM-- está funcionando y que el riesgo debido a contingencias es insignificante.[2] Este proceso se basa en un método de evaluación del riesgo con muestreo secuencial. Este método compara las desviaciones importantes de altitud reales, incluyendo los errores operacionales y los errores técnicos de vuelo, para poder determinar, con un alto nivel de confianza, si el sistema está cumpliendo con el TLS, si el sistema no está cumpliendo con el TLS o si se necesita más datos.

8.11.3 La evidencia obtenida del método de evaluación del riesgo con muestreo secuencial, tanto para la implantación de prueba a corto plazo como para el año 2005, será utilizada para demostrar si existe un alto grado de confianza en que se cumplirá con el TLS de 5×10^{-9} accidentes fatales por hora de vuelo en el ambiente RVSM o si se requiere vigilancia adicional de los errores de mantenimiento de altitud (excluyendo el ASE y las contingencias).

8.12 Performance del sistema global

8.12.1 Además del requisito que establece que la performance del sistema total debe cumplir con el TLS general, el proceso de vigilancia servirá para verificar que la flota de aeronaves que vuela en espacio aéreo RVSM cumple con la especificación de performance del sistema global de la que se derivaron la MASPS RVSM (ver también el párrafo 2.2 anterior).

8.12.2 Debido a que la especificación de performance de posición del sistema global y, especialmente, la $P_z(1000)$ de 1.7×10^{-8}, fueron utilizadas para derivar las especificaciones de performance de mantenimiento de altitud de las aeronaves, las cuales están expresadas como requisitos con respecto al TVE, este aspecto del programa de vigilancia sólo incluye los errores resultantes del incorrecto funcionamiento del equipo.

8.12.3 Hay dos métodos que se utilizan para evaluar el cumplimiento de los requisitos globales de mantenimiento de altitud por parte del TVE. Un método calcula directamente la proporción de TVEs de una determinada magnitud, mediante modelos de distribución estadística, y compara los resultados con los requisitos globales del TVE, y el otro método evalúa el cumplimiento de la MASPS.

8.13 Vigilancia y evaluación del cumplimiento de la MASPS

8.13.1 Con una medición del TVE y una diferencia simultánea entre la altitud notificada automáticamente en Modo C y el nivel de vuelo asignado o AAD, será posible desarrollar un estimado del ASE de una aeronave como la diferencia entre su TVE y AAD. Será importante derivar los valores del ASE para las células y para los tipos de aeronaves para evaluar los valores que conforman el TVE, es decir, el ASE y la AAD.

8.13.2 La MASPS fue diseñada para que el TVE resultante, medido en base a los valores que conforman el ASE y la AAD, genere una $P_z(1000)$ insignificante. Para evaluar el cumplimiento

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[2] El trabajo del RGCSP sugiere que el riesgo es insignificante cuando está, aproximadamente, dos órdenes de magnitud por debajo del TLS.

de la especificación de performance global de mantenimiento de altitud, se verificará las premisas básicas utilizadas en la derivación de la MASPS, y se vigilará la performance de los valores que conforman el ASE y la AAD en comparación con los requisitos de la MASPS (ver el párrafo 3.1.2). El Apéndice D describe la evaluación del ASE y la AAD para cumplir con la MASPS.

8.14 Evaluación de la seguridad operacional de las operaciones RVSM en el Caribe y Sudamérica

8.14.1 Los parámetros del espacio aéreo derivados de los procedimientos de vigilancia arriba descritos permiten evaluar el riesgo de colisión en el sistema, comparándolo con el TLS regional. También se puede evaluar la performance de mantenimiento de altitud de las aeronaves y compararla con los requisitos de la especificación de performance global de mantenimiento de altitud descritos en el párrafo 3.1.3 del presente documento.

8.14.2 Antes de la implantación de la RVSM en las Regiones del Caribe y Sudamérica, se usará técnicas matemáticas y estadísticas para brindar información detallada acerca de la performance de pronosticación del sistema en términos del riesgo de colisión y la performance de mantenimiento de altitud de las aeronaves. Luego de la implantación de la RVSM, se continuará vigilando los parámetros del CRM y evaluando la performance del sistema a fin de identificar y corregir rápidamente cualquier tendencia adversa.

8.14.3 Durante el período de verificación y después de la implantación, se utilizará la tabulación de detalles para brindar información pormenorizada sobre el pronóstico de datos de cuasicolisión, informes de cuasicolisión en vuelo o cualquier otra fuente similar de información del sistema en relación al riesgo de colisión y la performance de mantenimiento de altitud de las aeronaves.

8.15 Responsabilidades de la agencia regional de monitoreo

8.15.1 El monitoreo será llevado a cabo por la agencia regional de monitoreo, e incluirá el monitoreo de la precisión de mantenimiento de altitud y de los errores verticales. Las tareas adicionales son las siguientes:

a) transferir y cotejar los datos sobre la performance de mantenimiento de altitud de las aeronaves obtenidos de otras agencias de monitoreo;

b) recibir notificaciones de los sistemas de vigilancia de altitud sobre las desviaciones de altitud cuyos valores sean iguales o superiores a los siguientes criterios:

   i) TVE : 300 ft;

   ii) ASE : 245 ft; ó

   iii) AAD : 300 ft;

c) recibir notificaciones de los Estados proveedores sobre los detalles de los errores operacionales y desviaciones importantes de altitud identificados en la región;

d) tomar las medidas necesarias con el Estado o explotador pertinente a fin de:

i) determinar la causa probable de la desviación de altitud; y

ii) verificar la situación de aprobación del explotador pertinente;

e) recomendar, cuando sea posible, medidas correctivas;

f) analizar datos con el objeto de detectar tendencias de desviaciones de altitud y adoptar las medidas indicadas en d) ;

g) efectuar las compilaciones de datos necesarias con el objeto de:

  i) investigar la performance de mantenimiento de altitud de las aeronaves en la parte central de la distribución;

  ii) establecer una base de datos (o introducir datos adicionales) sobre la performance de mantenimiento de altitud de:

  a) la población de aeronaves;

  b) los tipos o categorías de aeronaves; y

  c) las células tomadas individualmente;

  iii) brindar datos adicionales sobre la performance de mantenimiento de altitud que se requieran para llevar a cabo los estudios que se considere necesarios. Tales estudios podrían incluir el análisis del FTE en el espacio aéreo, basado en el examen de los registros de los datos de vuelo;

h) recolectar datos sobre todos los vuelos que ingresan a la región desde todos los Estados proveedores. Estos datos deberían incluir los números de matrícula de las aeronaves a fin de facilitar la verificación de la situación de aprobación tomando como referencia una base de datos de los usuarios aprobados;

i) vigilar el nivel de riesgo de colisión como consecuencia de errores operacionales y técnicos y procedimientos de emergencia de la manera siguiente:

  i) establecer un mecanismo para recibir todos los informes sobre desviaciones de altitud de 90 m (300 ft) o más ocasionadas por los mencionados errores y/o procedimientos;

  ii) determinar, de ser posible, la causa fundamental de la desviación, así como su magnitud y duración;

  iii) calcular la frecuencia de sucesos;

  iv) evaluar el nivel de riesgo en el ambiente RVSM;

  v) comparar el nivel de riesgo debido a errores operacionales con el nivel experimentado en el ambiente de 600 m (2000 ft); e

  vi) iniciar medidas correctivas;

j) mantener una base central de datos sobre los usuarios aprobados, e iniciar verificaciones sobre la “situación de aprobación” de las aeronaves que operan en el ambiente RVSM en cuestión; y

k) distribuir informes mensuales sobre todas las desviaciones relacionadas con el mantenimiento de altitud, así como los gráficos y tablas necesarios para ilustrar la relación estimada entre el riesgo del sistema y el TLS.

8.15.2 La Agencia de Monitoreo del Caribe y Sudamérica (CARSAMMA) es el organismo de vigilancia en las Regiones del Caribe y Sudamérica. La CARSAMMA tiene la responsabilidad de recolectar, cotejar y difundir los datos relacionados con la performance de navegación.

Además, actúa como punto focal para las notificaciones sobre desviaciones de 300 pies o más. Si bien existe un procedimiento formalizado y universalmente acordado para manejar los errores graves de navegación (GNE), aún no existe un procedimiento oficial semejante para manejar las desviaciones de altitud. Por lo tanto, durante y después de la fase de verificación de la RVSM, la agencia regional de monitoreo, además de sus tareas existentes, tendrá las siguientes responsabilidades:

a) iniciar la verificación de la situación de aprobación de las aeronaves que operan en el ambiente RVSM, mediante una vigilancia táctica del espacio aéreo;

b) mantener una base de datos sobre las aeronaves aprobadas para operar en espacio aéreo RVSM, incluyendo detalles de la performance observada a través del GMS;

c) mantener una base de datos sobre las aeronaves "inobservantes", recopilada de todas las fuentes de vigilancia;

d) mantener cualquier otra base de datos que fuera necesaria para vigilar el TLS en relación a los criterios de performance de mantenimiento de altitud observada;

e) tomar las medidas necesarias para garantizar el cumplimiento de las metas mínimas de vigilancia de aeronaves;

f) hacer el seguimiento e iniciar la investigación de las desviaciones de altitud que excedan una magnitud predeterminada, y recomendar acciones correctivas; y

g) preparar informes de rutina y difundir los datos de vigilancia, según se requiera.

8.16 Objetivos del sistema de vigilancia de altitud

8.16.1 Para poder recomendar un sistema de vigilancia, primero fue necesario definir las metas generales de vigilancia. Luego de revisar la información y los datos recolectados en los programas de estudios verticales, se asumió que, para fines de planificación, el ASE para las células individuales permanecería invariable por un período de dos años. Por lo tanto, los principales objetivos del período de verificación fueron la caracterización de la performance con respecto al ASE de las células que serán utilizadas en las Regiones del Caribe y Sudamérica para operaciones RVSM, y la confirmación de la estabilidad del ASE. La estabilidad del ASE sigue siendo evaluada mediante la vigilancia de las aeronaves en la Región NAT y en otros espacios aéreos RVSM.

8.16.2 En base a la premisa anterior, fue posible establecer los objetivos del programa de vigilancia y analizar cómo se podría alcanzar dichos objetivos. En primer lugar, el objetivo final sería la realización de un censo completo de las células. Por lo tanto, el sistema de vigilancia debería estar diseñado para que, en principio, pueda llevar a cabo dicho censo en el lapso de un año. Debido a que un censo completo constituye una meta poco práctica para la fase de verificación, la Región NAT acordó los siguientes objetivos mínimos. Estos objetivos también deberían permitir la recolección de suficiente información sobre la performance de mantenimiento de altitud de las aeronaves que operan en las Regiones del Caribe y Sudamérica:

a) medir suficientes células como para garantizar que un mínimo de 90% de los vuelos realizados en un año en las Regiones del Caribe y Sudamérica serán realizados por aeronaves que hayan sido vigiladas por lo menos una vez;

b) vigilar no menos de 60% de todas las células aprobadas según la MASPS RVSM, por lo menos una vez durante la fase de verificación, a través del proceso de vigilancia de la RVSM en el Caribe y Sudamérica;

c) realizar, por lo menos, un censo de los tipos de aeronaves aprobados según la MASPS RVSM;

d) realizar, por lo menos, un censo de los tipos de aeronaves aprobados según la MASPS RVSM, por cada explotador comercial; y

e) medir la mayor cantidad posible de aeronaves de la aviación general internacional (IGA) aprobadas según la MASPS RVSM, y no menos de 80% de la población total de dichas aeronaves. Se debería hacer un esfuerzo extraordinario por realizar un censo de las aeronaves IGA aprobadas según la MASPS RVSM.

8.16.3 Es posible que un análisis de los explotadores y tipos de aeronaves que operan en el espacio aéreo del Caribe y Sudamérica revele que muchas aeronaves ya han sido materia de vigilancia mientras operaban en el entorno RVSM de la Región NAT, y que ahora es posible lograr el objetivo de un censo de las aeronaves que tiene intenciones de operar en el entorno RVSM del Caribe y Sudamérica. En ese caso, se debería modificar las metas de vigilancia para aumentar las probabilidades de realizar un censo durante el período de verificación del Caribe y Sudamérica.

8.16.4 Las metas de vigilancia de la Región NAT fueron diseñadas como objetivos mínimos con el fin de asegurar una buena muestra representativa de aeronaves que cumplen con la MASPS RVSM. Los datos obtenidos de un programa de vigilancia que cumple con estas metas serían suficientes para brindar:

a) mayores evidencias de la estabilidad del ASE;

b) orientación sobre la eficacia de la MASPS RVSM y la efectividad de las modificaciones del sistema altimétrico;

c) la seguridad que la performance de mantenimiento de altitud de las aeronaves, según las mediciones de la Región NAT, se puede transferir al espacio aéreo del Caribe y Sudamérica; y

d) confianza en el cumplimiento del TLS.

8.16.5 Las metas fueron acordadas bajo el supuesto que la performance de mantenimiento de altitud de las aeronaves cumpliría con los requisitos globales. Así, el riesgo de colisión debido a este aspecto del sistema sería una contribución muy pequeña al TLS regional. Si la performance observada es muy inferior a los requisitos globales de mantenimiento de altitud, se incrementará los requisitos mínimos de muestreo para asegurar que el TLS regional no se vea amenazado.

8.17 Descripción del sistema de vigilancia de altitud de la Región NAT

8.17.1 El sistema de vigilancia de altitud para la implantación de la RVSM en la Región NAT consistió en un sistema híbrido de vigilancia de altitud compuesto por HMUs y un GMS. El GMS estaba conformado por GMUs portátiles, estaciones de referencia GPS, acceso al Modo C e información MET, instalaciones de procesamiento posterior al vuelo y un adecuado apoyo logístico.

8.17.2 Para la aplicación de la RVSM en el espacio aéreo inicial, hubiera sido muy difícil alcanzar los objetivos de vigilancia con sólo uno de los sistemas de vigilancia propuestos - el HMU ó el GMS. Los HMUs permitieron obtener una amplia muestra de células en un corto período. Se recolectó muestras repetidas de las aeronaves individuales en el espacio RVSM de la Región NAT a lo largo de extensos períodos de tiempo para ayudar a verificar la premisa de la estabilidad del ASE y caracterizar el rango típico de ASE para una gama de tipos de aeronaves. Las aeronaves que no fueron vigiladas con el sistema HMU fueron candidatas para la vigilancia con el GMS. El GMS permitía mediciones repetidas de células de las que no se tenía la seguridad de su cumplimiento, y la concentración de la vigilancia en sub-poblaciones con una performance deficiente comprobada. Asimismo, se utilizó el GMS para obtener muestras de los explotadores y/o tipo de aeronaves que, en sus operaciones normales, no sobrevolaban el emplazamiento geográfico de un HMU.

8.17.3 Además, la limitación de la ubicación fija del HMU se veía compensada con la capacidad del GMS de acomodarse a cada aeronave. En consecuencia, un sistema combinado facilitó la realización de un censo completo, por explotador, tipo o célula. Asimismo, el costo unitario relativamente alto del HMU se vió compensado con el menor costo de un GMS complementario.

8.17.4 El volumen relativamente bajo de datos recolectados diariamente por el GMS se vio compensado con la alta tasa diaria de adquisición de datos del HMU. Mientras que la performance de una aeronave vigilada mediante el GMS puede no haber sido la típica "en ese momento", las aeronaves vigiladas pasivamente mediante el HMU tenían más probabilidades de ser representativas de su performance normal. Los problemas administrativos y/o logísticos previstos en la operación de un GMS autónomo se vieron ampliamente reducidos gracias al aporte complementario del sistema HMU.

8.17.5 Por lo tanto, las desventajas del sistema HMU fueron mitigadas por las características del GMS y las desventajas del GMS fueron compensadas por las características del sistema HMU. Además, el sistema ofrecía ventajas independientes adicionales. La combinación de los HMU y el GMS ofrecía el mejor medio para alcanzar los objetivos de verificación y vigilancia en el entorno RVSM de la Región NAT. No obstante, se reconoció que, debido a los sistemas complementarios, ambos elementos (HMU/GMS) eran igualmente esenciales para la composición del sistema híbrido.

8.18 Descripción del sistema de vigilancia de altitud del Caribe y Sudamérica

8.18.1 No es seguro que se cuente con un sistema de emplazamiento fijo del tipo HMU en las Regiones del Caribe y Sudamérica, con lo cual se corre el riesgo de perder las ventajas del sistema híbrido de vigilancia. Si bien el tamaño de la población de explotadores y de tipos de aeronaves indica que debería poder alcanzarse las metas de vigilancia mediante el GMS, sería necesario incorporar algunas de las características del HMU en el GMS, entre las cuales figuran:

a) mediciones repetidas de las células para asegurar la estabilidad del ASE;

b) vigilancia constante de las aeronaves para asegurar que se mantiene la performance de mantenimiento de altitud. En los datos de la Región NAT, se encontró ASEs importantes en tres tipos de aeronaves que habían recibido la aprobación de aeronavegabilidad. Si bien se corrigió el problema en cada una de las células, aún se desconoce la causa de las fallas; y

c) la garantía continua de que el riesgo del sistema se mantiene a un nivel inferior al TLS.

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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:

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

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

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

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. Maintenance Practices for Noncompliant Aircraft. 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.

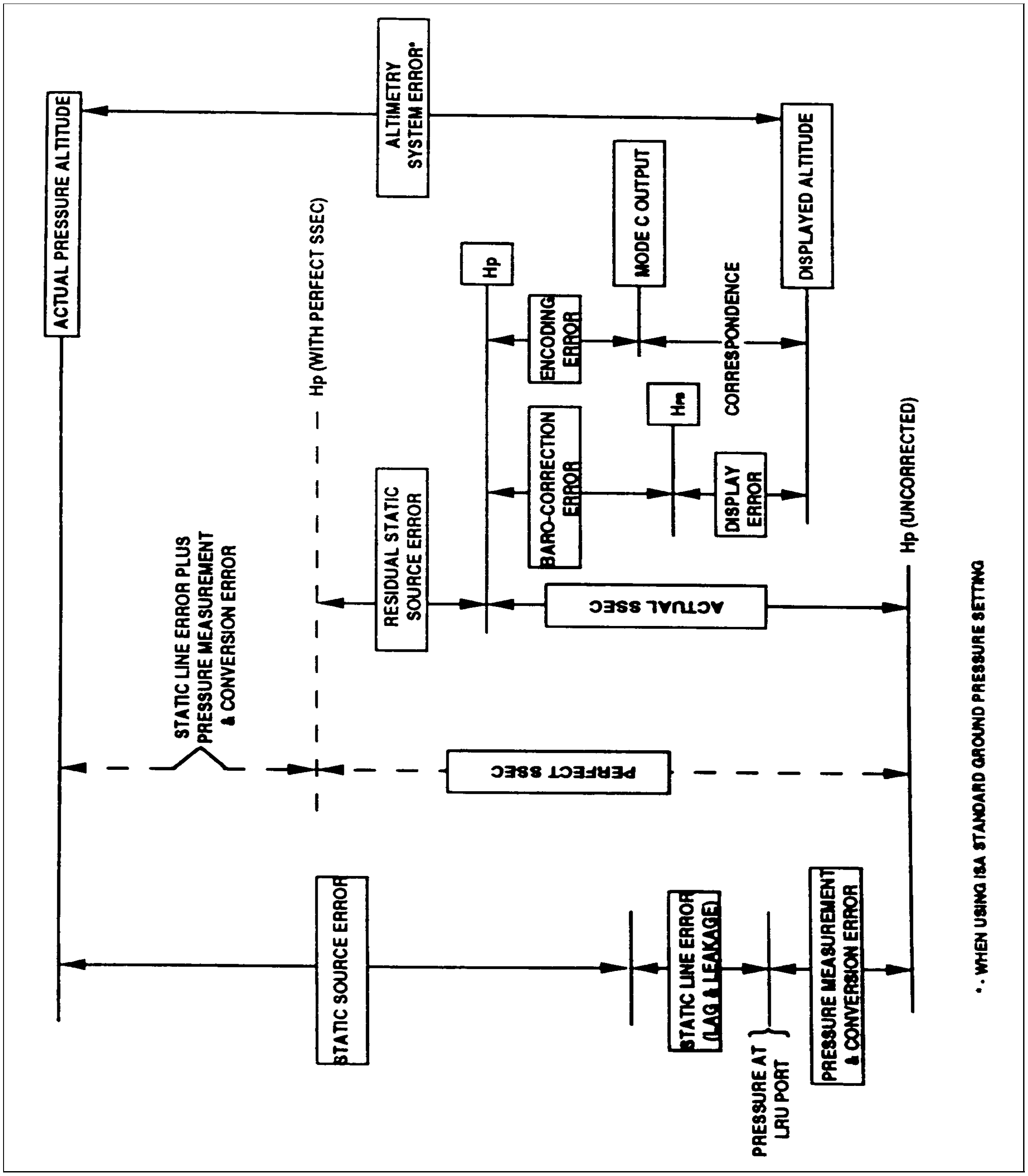
(1) The "Actual Altitude" is the pressure altitude corresponding to the undisturbed ambient pressure.

(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. Components. The altimetry system errors presented in table 2-1 and described in paragraph 3a are discussed below in greater detail.

(1) Static Source Error. 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, ∝, β) 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, ∝, β) 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

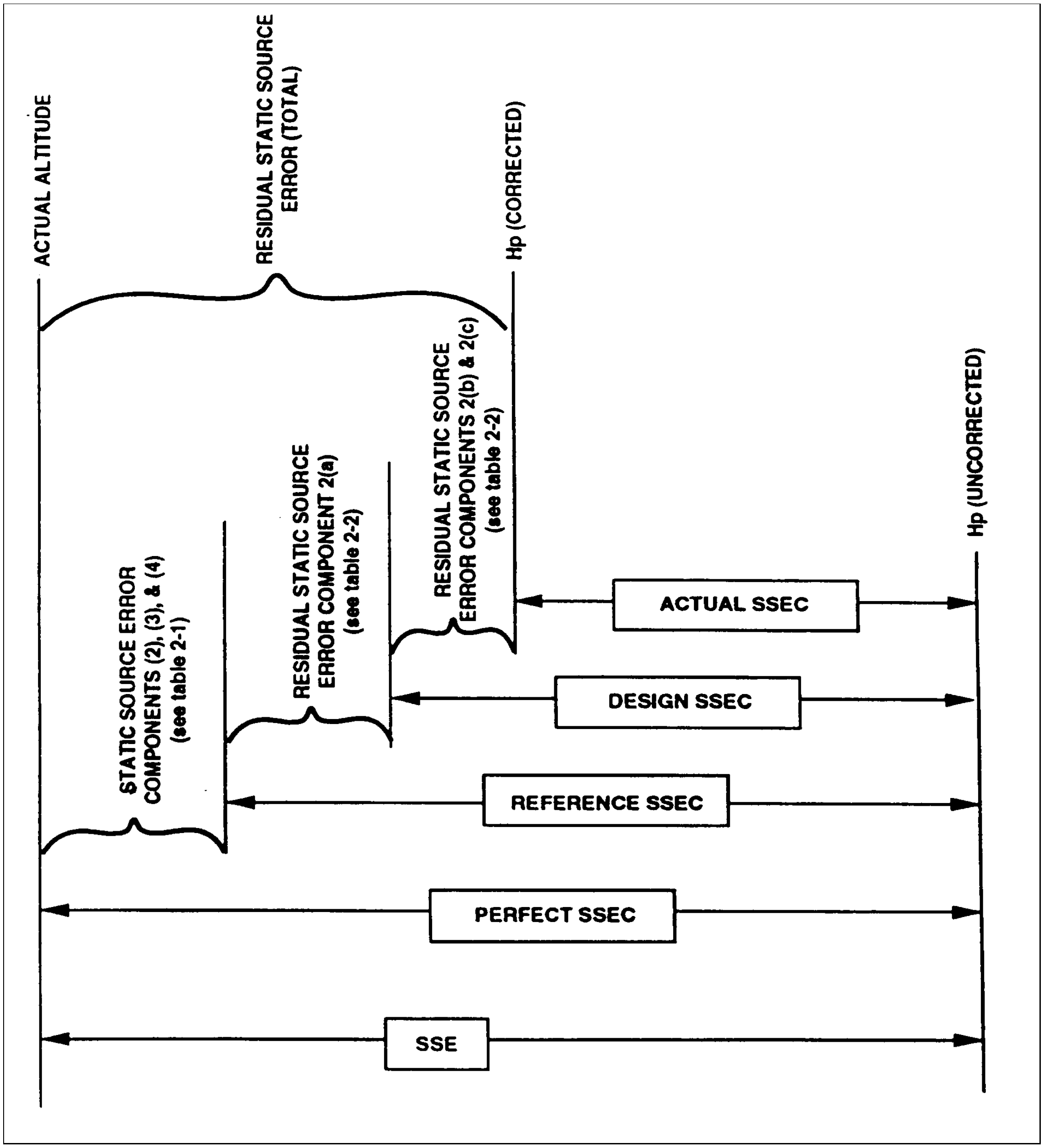
Table 2-2. Residual Static Source Error (Aircraft with Avionic SSEC)

(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.

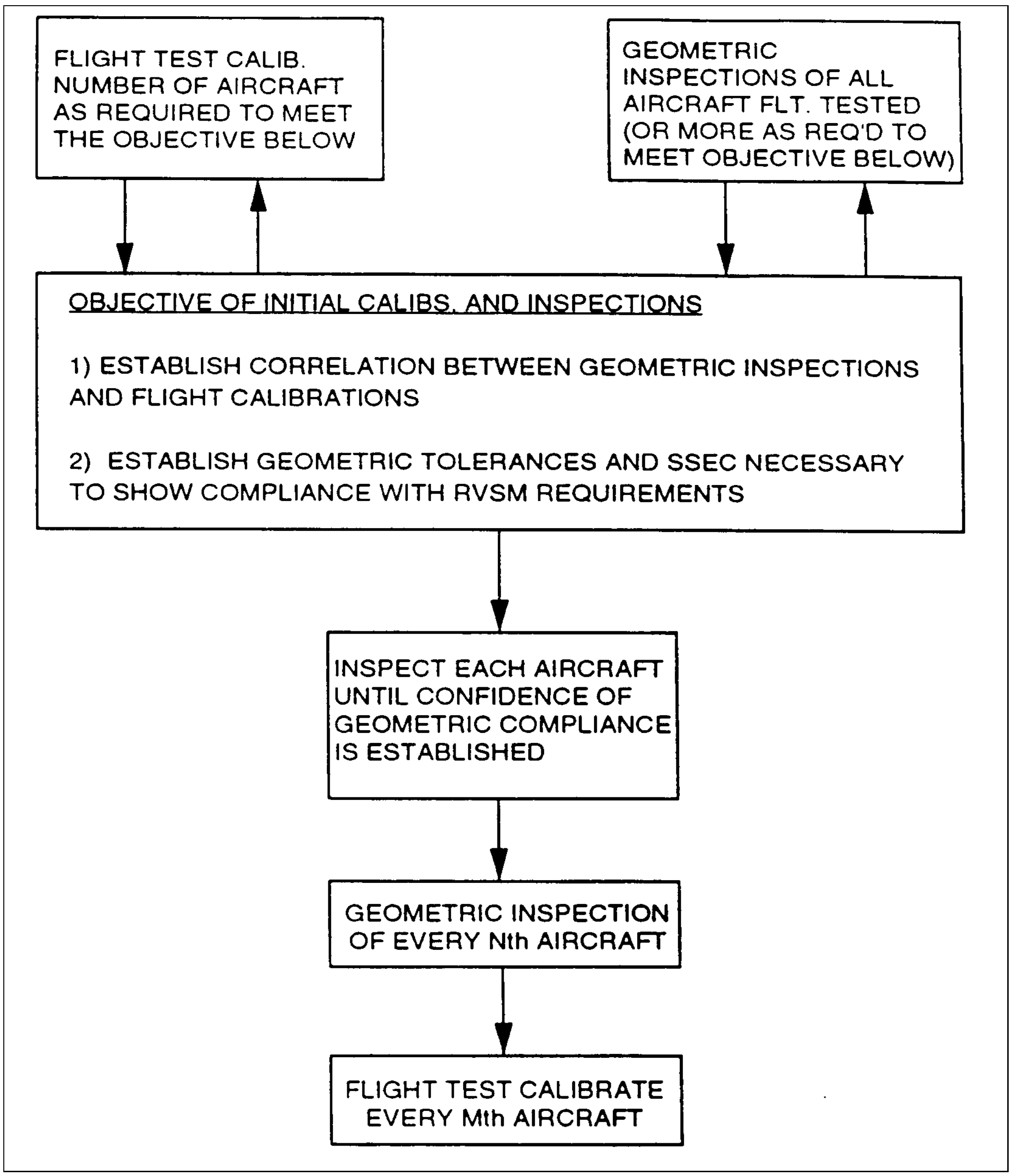
a. Figure 3-3 illustrates that flight test calibrations should be performed on a given number of aircraft and consistency rules for air data information between all concerned systems verified. Geometric tolerances and SSEC should be established to satisfy the requirements. A correlation should be established 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

APPENDIX 3: ESTABLISHING AND MONITORING STATIC SOURCE ERRORS

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 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

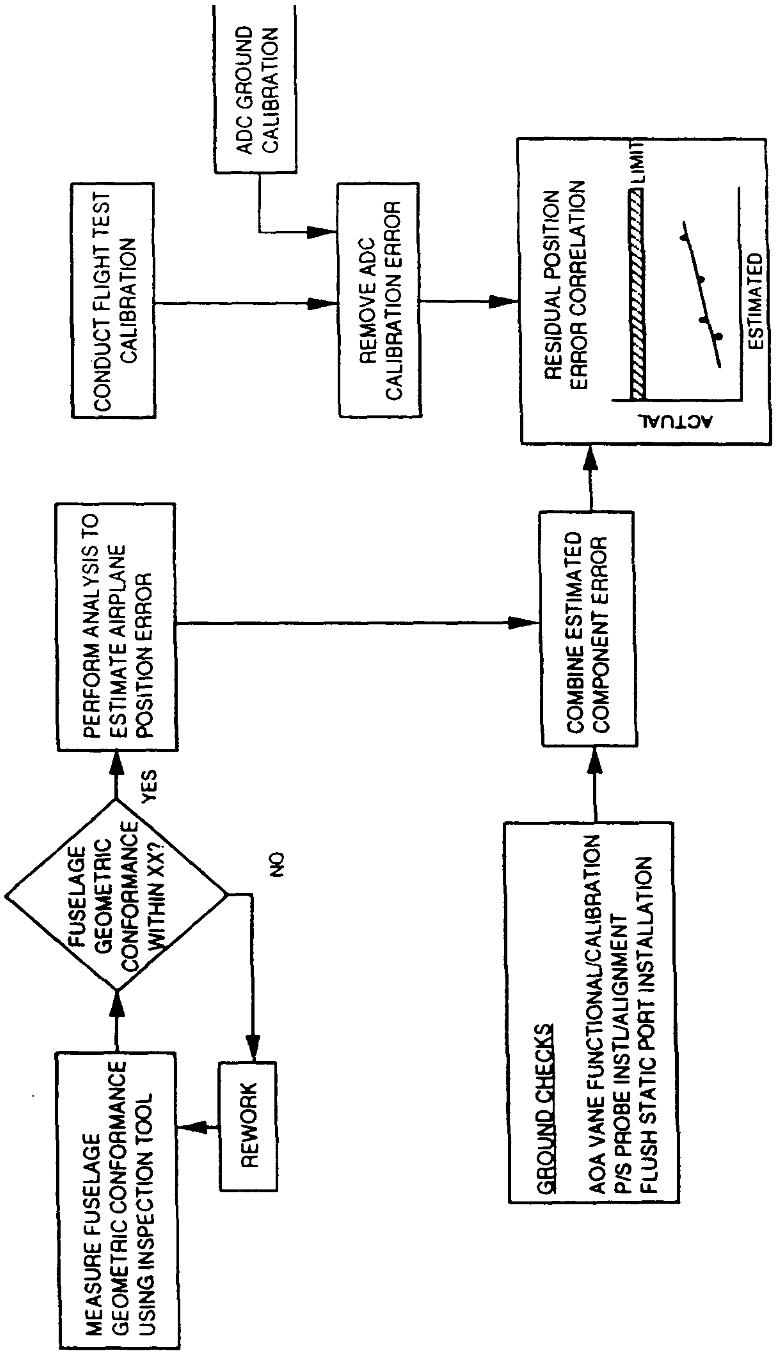
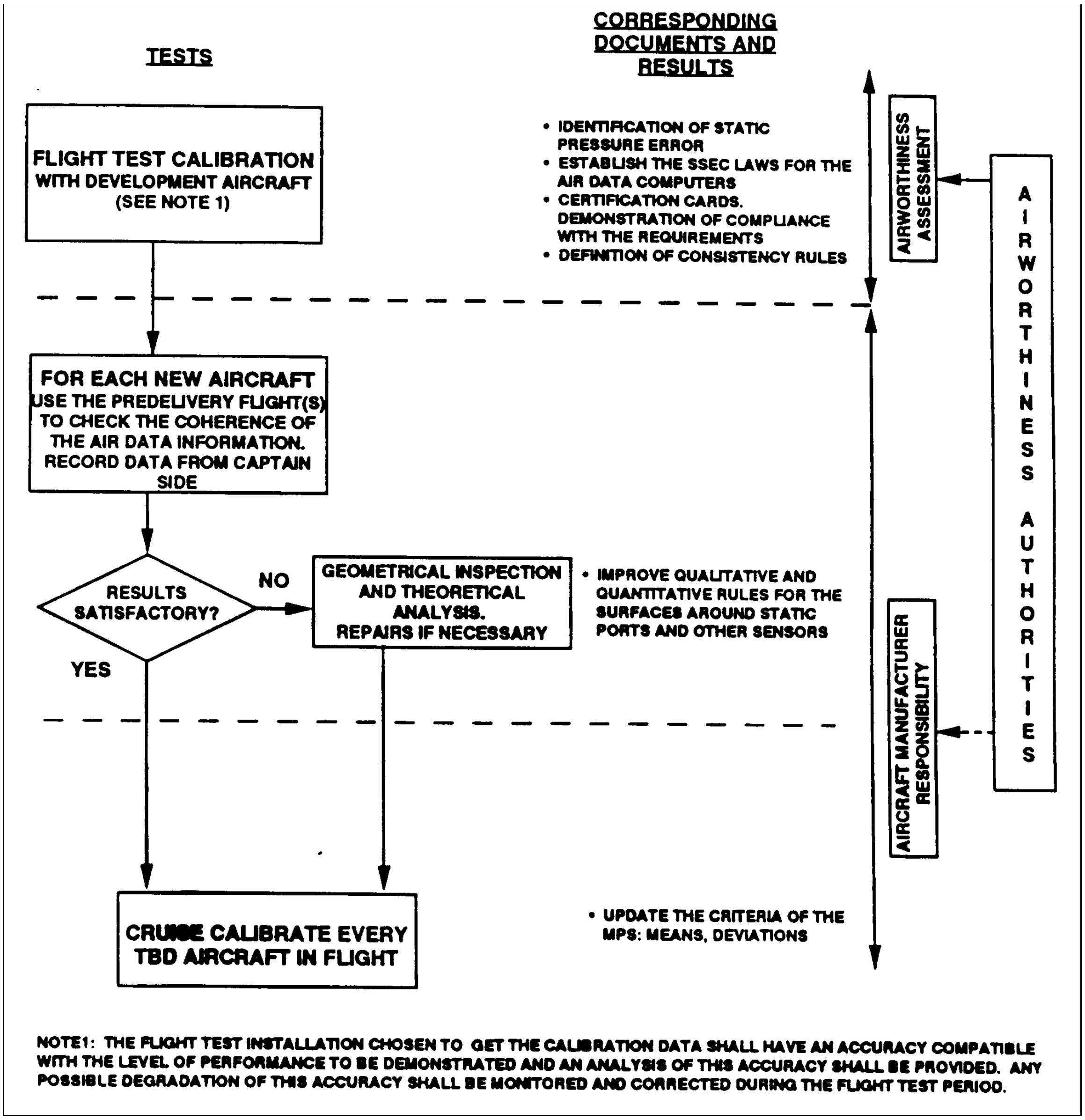


Figure 3-2. Compliance Demonstration Ground-to-flight Test Correlation Process Example.

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



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).

Note. *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 Post Flight.

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

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

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.

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

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.

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

* (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.

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

<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.

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

*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.

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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.

***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

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

	traffic information, notify other aircraft in the vicinity and continue to monitor the situation.
	4) Notify adjoining ATC facilities/sectors of the situation.

***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.

APPENDIX 5. SPECIFIC PROCEDURES FOR OCEANIC AIRSPACE

The Pilot should	**ATC can be expected to**
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.

*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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- END -

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.
$\overline{\lvert\Delta V\rvert}$	Average relative along track speed between aircraft on same direction routes.
$\overline{\lvert V\rvert}$	Average aircraft ground speed.
$\overline{\lvert\dot{y}\rvert}$ Appendix B – Collision Risk Modeling for the Vertical Dimension	Average relative cross track speed for an aircraft pair nominally on the same track.
$\overline{\lvert\dot{z}\rvert}$	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:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\overline{\dot{y}}|}{|\overline{\Delta V}|} + \frac{\lambda_x}{\lambda_z}\frac{|\overline{\dot{z}}|}{|\overline{\Delta V}|}\right]$$

and

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\overline{\dot{y}}|}{2|\overline{V}|} + \frac{\lambda_x}{\lambda_z}\frac{|\overline{\dot{z}}|}{2|\overline{V}|}\right]$$

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 $\leq$ 4000ft/ min($\cong$ 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:

$$\hat{N}_{az} = P_y(0)\frac{2N_{fl}(s)}{T}\frac{\lambda_x\lambda_z}{S_x|\overline{\dot{z}_1}|}\left\{E_z(same)\left[\frac{|\overline{\Delta V}|}{2\lambda_x} + \frac{|\overline{\dot{y}}|}{2\lambda_y} + \frac{|\overline{\dot{z}_1}|}{2\lambda_z}\right] + E_z(opp)\left[\frac{|\overline{V}|}{\lambda_x} + \frac{|\overline{\dot{y}}|}{2\lambda_y} + \frac{|\overline{\dot{z}_1}|}{2\lambda_z}\right]\right\}$$

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 ($\cong$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 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:

$$\hat{N}_{az} = \frac{2P_z(S_z)}{kF} \sum_{j=1}^{N} n_j P_o(s_j) \left[1 + \frac{|\bar{\dot{z}}|}{2\lambda_z} \overline{d_o(s_j)} \right]$$

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

$$\left[\frac{(j-1)t_M}{N}, \frac{jt_M}{N}\right), \quad \text{for } j = 1,2,\ \ldots,\ N;$$

s_j = $\dfrac{(2j-1)t_M}{2N}$ = the midpoint of the interval $\left[\dfrac{(j-1)t_M}{N}, \dfrac{jt_M}{N}\right]$

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 Caribbean and South American 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
$2\lambda_x$	$2\lambda_x + \Gamma_x$
$2\lambda_y$	$2\lambda_y + \Gamma_y$
$2\lambda_z$	$2\lambda_z + \Gamma_z$
$P_y(0) = \int_{-\lambda_y}^{\lambda_y} \int_{-\infty}^{\infty} h(y)h(y+w)dydw$	$P_y(0) = \int_{-(\lambda_y+\Gamma_y)}^{(\lambda_y+\Gamma_y)} \int_{-\infty}^{\infty} h(y)h(y+w)dydw$
$P_z(S_z) = \int_{S_z-\lambda_z}^{S_z+\lambda_z} \int_{-\infty}^{\infty} f(z)f(z+w)dzdw$	$P_z(S_z) = \int_{S_z-\lambda_z-\Gamma_z}^{S_z+\lambda_z+\Gamma_z} \int_{-\infty}^{\infty} f(z)g(z+w)dzdw$

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 Caribbean and South American 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 1000ft 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 a 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 Caribbean and South American 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).

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PREAMBLE

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

The revised material of this leaflet is derived directly from IL 23. The material has been updated to reflect the current status of RVSM operations in general, and to add guidance concerning the application of RVSM within designated airspace in the EUR region (referred to as European RVSM airspace) as defined in ICAO Doc 7030. 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 x 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 x 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
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

Abbreviation	Meaning
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.

11.4 Demonstration Flight(s)

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

11.5 Form of Approval Documents

(a) *Holders of an Air Operator's Certificate* Approval to operate in designated RVSM airspace areas will be granted by an Approval issued by the responsible authority in accordance with JAR OPS 1, or in compliance with national 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.

11.6 Airspace Verification/Monitoring Programmes

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.

11.7 Suspension or Revocation of RVSM Approval

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

(a) TVE equal to or greater than ±90 m (±300 ft),

(b) ASE equal to or greater than ±75 m (±245 ft), and

(c) Assigned altitude deviation equal to or greater than ±90 m (±300 ft).

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

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

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

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

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

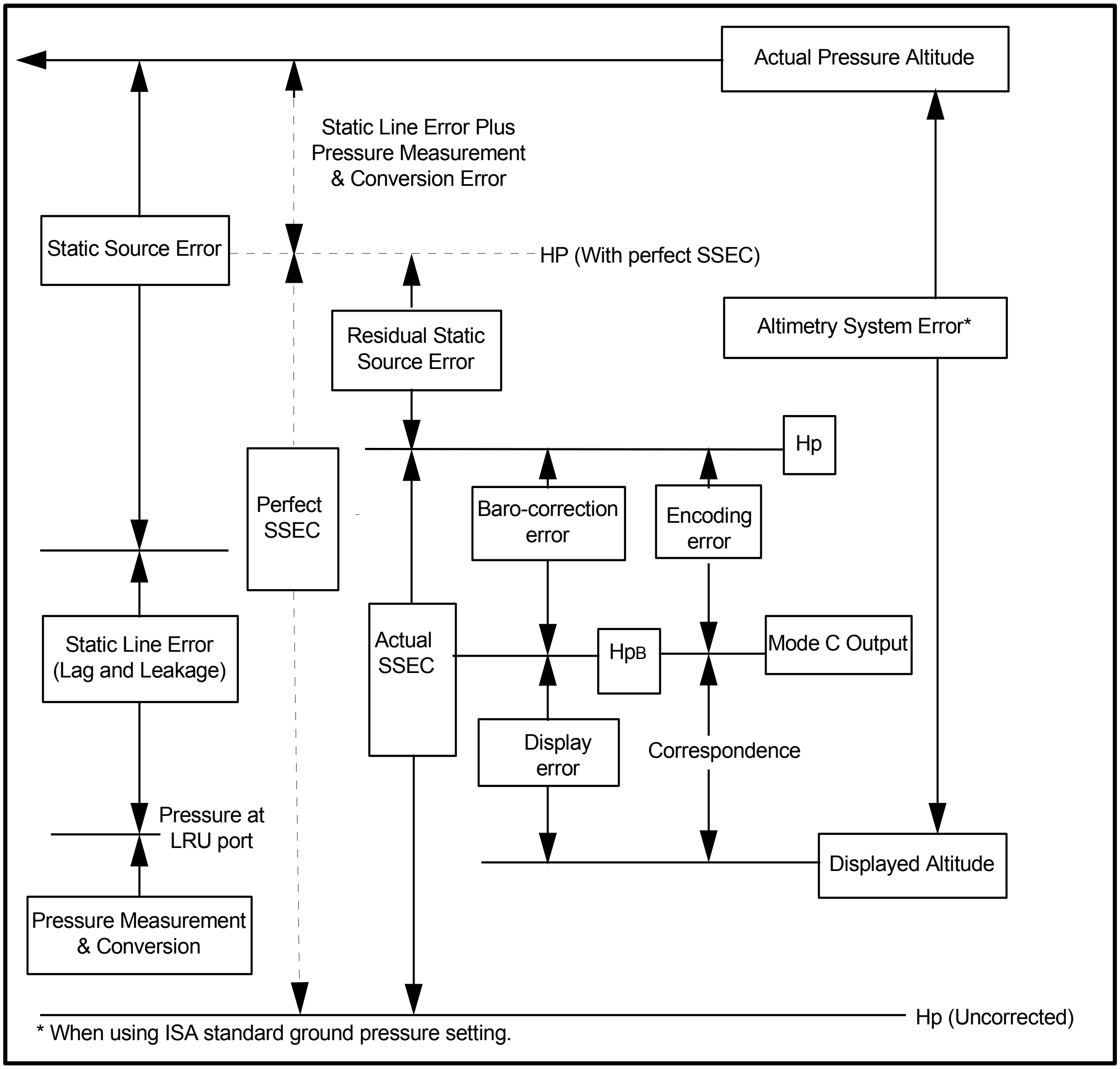
(d) 'Pressure Measurement and Conversion Error' is the error associated with the processes of sensing the pneumatic input seen by the avionics, and converting the resulting pressure signal into altitude. As drawn, Figure 2-1 represents a self-sensing altimeter system in which the pressure measurement 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.

(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.

FIGURE 2-1 ALTIMETRY SYSTEM ERRORS



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.

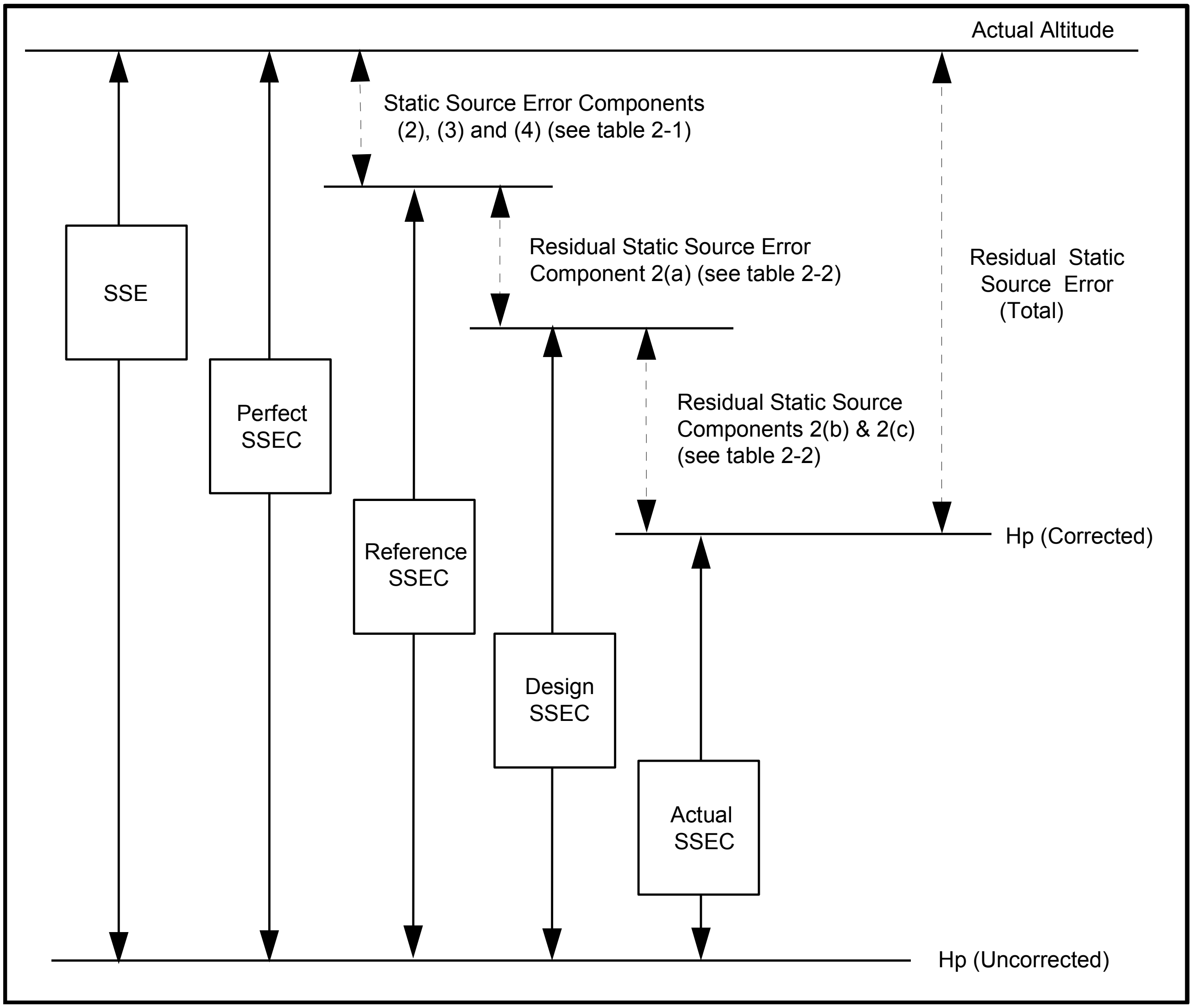
TABLE 2-1 STATIC SOURCE ERROR
(Cause: Aerodynamic Disturbance to Free-Stream Conditions)

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

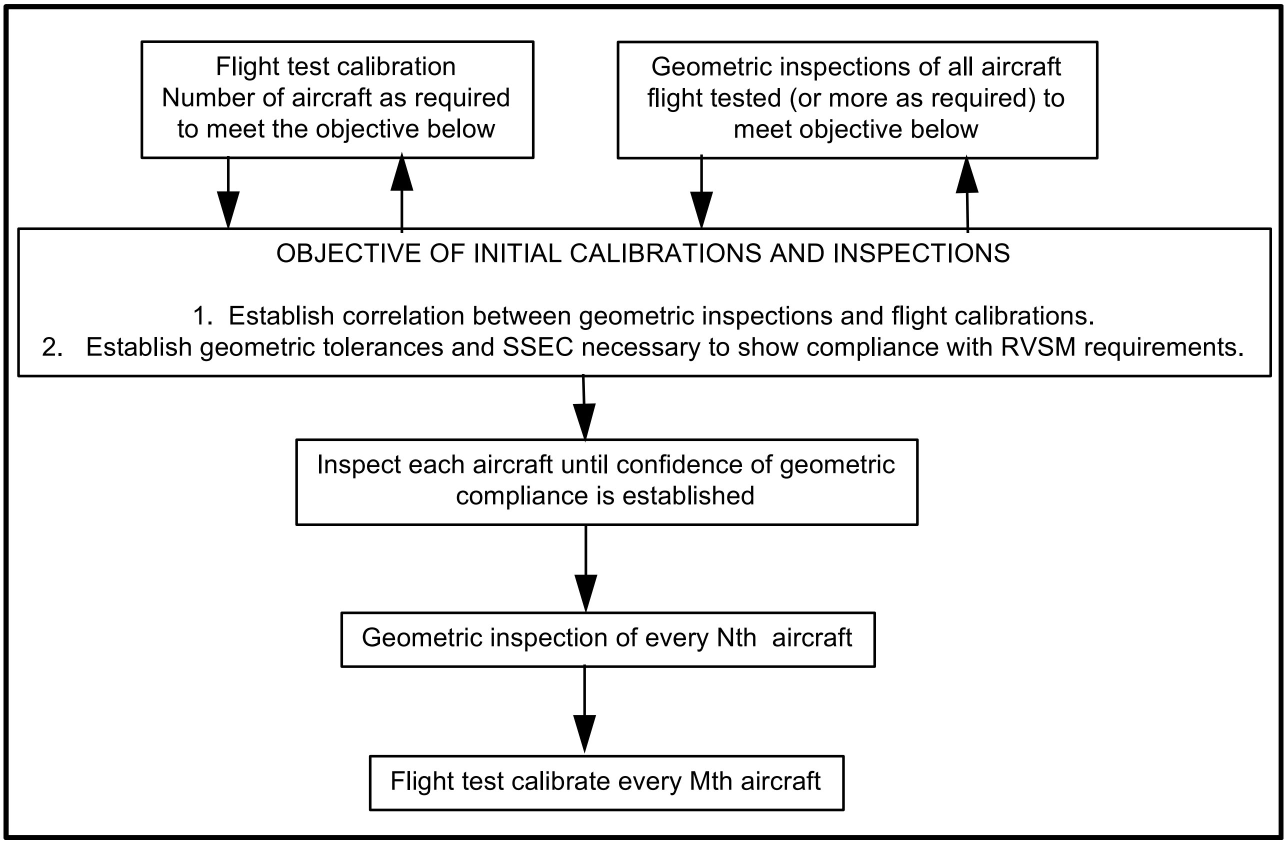


FIGURE 3-2 COMPLIANCE DEMONSTRATION GROUND - TO FLIGHT TEST CORRELATION PROCESS EXAMPLE

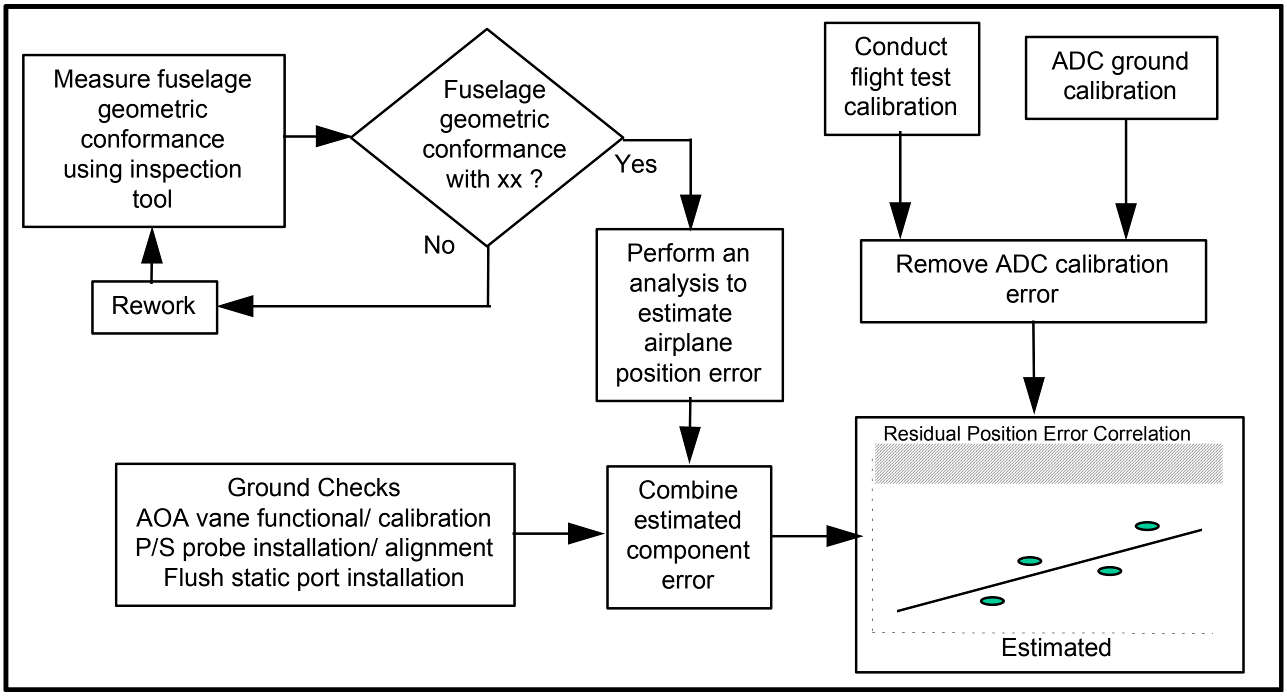
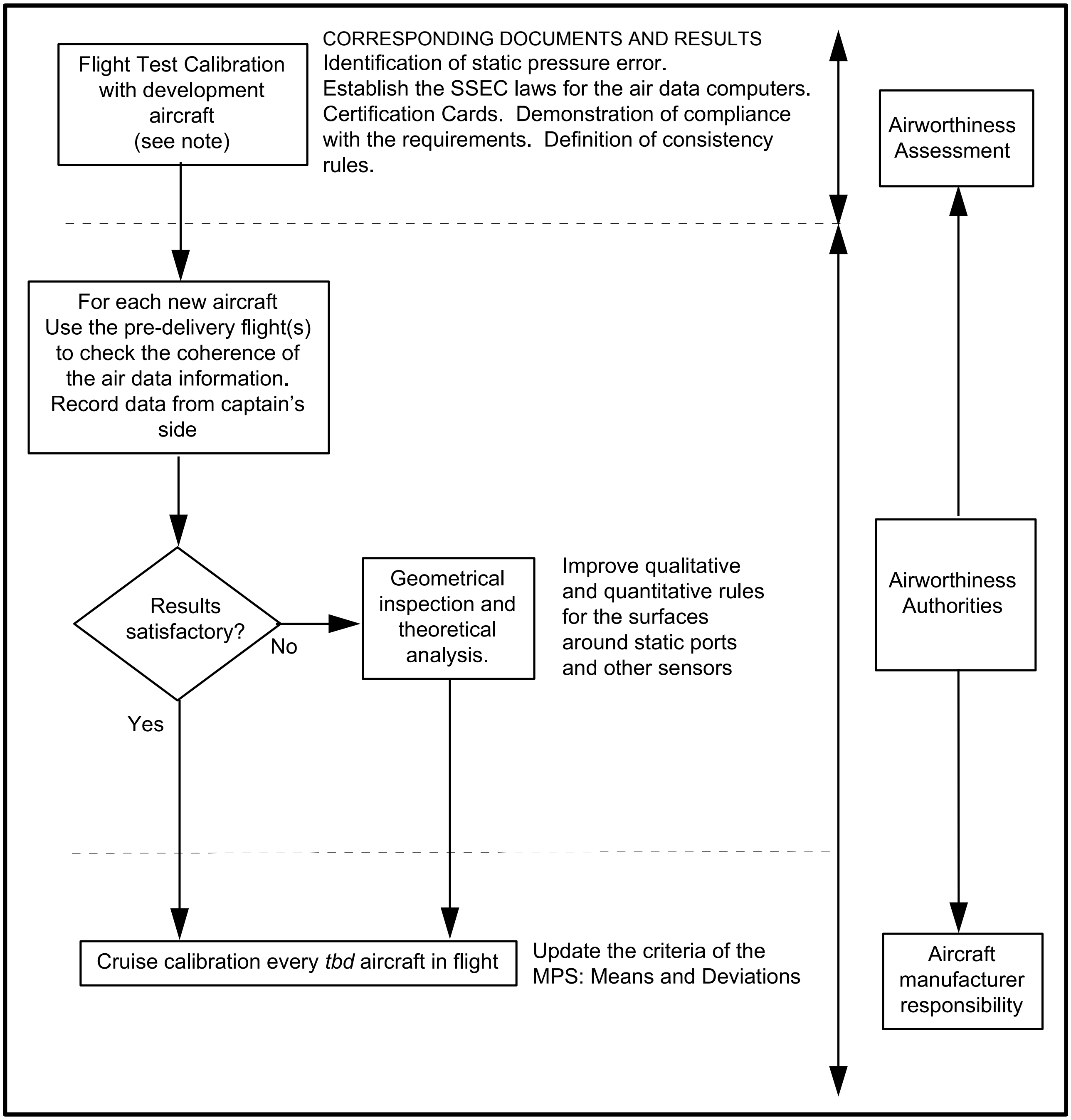


FIGURE 3-3 PROCESS FOR SHOWING INITIAL AND CONTINUED COMPLIANCE OF AIRFRAME STATIC PRESSURE SYSTEMS FOR NEW MODEL AIRCRAFT.



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

APPENDIX 4 TRAINING PROGRAMMES AND OPERATING PRACTICES AND PROCEDURES

1. INTRODUCTION

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

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

2. FLIGHT PLANNING

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

These include, but may not be limited to:

(a) verifying that the airframe is approved for RVSM operations;

(b) reported and forecast weather on the route of flight;

(c) minimum equipment requirements pertaining to height keeping and alerting systems; and

(d) any airframe or operating restriction related to RVSM approval.

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

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

(a) review technical logs and forms to determine the condition of equipment required for flight in the RVSM airspace. Ensure that maintenance action has been taken to correct defects to required equipment;

(b) during the external inspection of aircraft, particular attention should be paid to the condition of static sources and the condition of the fuselage skin near each static source and any other component that affects altimetry system accuracy. This check may be accomplished by a qualified and authorised person other than the pilot (e.g. a flight engineer or ground engineer);

(c) before takeoff, the aircraft altimeters should be set to the QNH of the airfield and should display a known altitude, within the limits specified in the aircraft operating manuals. The two primary altimeters should also agree within limits specified by the aircraft operating manual. An alternative procedure using QFE may also be used. Any required functioning checks of altitude indicating systems should be performed.

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

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

4. PROCEDURES PRIOR TO RVSM AIRSPACE ENTRY

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

(a) Two primary altitude measurement systems.

(b) One automatic altitude-control system.

(c) One altitude-alerting device.

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

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

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

5. IN-FLIGHT PROCEDURES

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

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

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

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

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

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

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

(f) Ensure that the altitude-alerting system is operative;

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

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

(ii) Before entering RVSM airspace, the initial altimeter cross check of primary and standby altimeters should be recorded

Note: Some systems may make use of automatic altimeter comparators.

(h) In normal operations, the altimetry system being used to control the aircraft should be selected for the input to the altitude reporting transponder transmitting information to ATC.

(i) If the pilot is advised in real time that the aircraft has been identified by a height-monitoring system as exhibiting a TVE greater than ±90 m (±300 ft) and/or an ASE greater than ±75 m (±245 ft) then the pilot should follow established regional procedures to protect the safe operation of the aircraft. This assumes that the monitoring system will identify the TVE or ASE within the set limits for accuracy.

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

<u>5.2 Contingency procedures after entering RVSM airspace are:</u>

5.2.1 The pilot should notify ATC of contingencies (equipment failures, weather) which affect the ability to maintain the cleared flight level, and co-ordinate a plan of action appropriate to the airspace concerned. Appendices 6 and 7 are relevant to EUR and NAT airspace.

Note: Other appendices may be added as necessary to address additional areas of operation.

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

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

(b) loss of redundancy of altimetry systems;

(c) loss of thrust on an engine necessitating descent; or

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

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

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

6. POST FLIGHT

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

6.2 The following information should be recorded when appropriate:

(a) Primary and standby altimeter readings.

(b) Altitude selector setting.

(c) Subscale setting on altimeter.

(d) Autopilot used to control the aeroplane and any differences when an alternative autopilot system was selected.

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

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

(g) The transponder selected to provide altitude information to ATC and any difference noted when an alternative transponder was selected.

7. SPECIAL EMPHASIS ITEMS: FLIGHT CREW TRAINING

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

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

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

(c) use and limitations in terms of accuracy of standby altimeters in contingencies. Where applicable, the pilot should review the application of static source error correction/ position error correction through the use of correction cards;
Note: Such correction data will need to be readily available on the flight deck.

(d) problems of visual perception of other aircraft at 300m (1,000 ft) planned separation during darkness, when encountering local phenomena such as northern lights, for opposite and same direction traffic, and during turns; and

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

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

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

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

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

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

(a) 'the proportion of height keeping errors beyond 90 m (300 ft) in magnitude must be less than 2.0×10^{-3}; and

(b) the proportion of height keeping errors beyond 150 m (500 ft) in magnitude must be less than 3.5×10^{-6}; and

(c) the proportion of height keeping errors beyond 200 m (650 ft) in magnitude must be less than 1.6×10^{-7}; and

(d) the proportion of height keeping errors between 290 m (950 ft) and 320 m (1,050 ft) in magnitude must be less than 1.7×10^{-8}.'

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

(a) 'The mean altimetry system error (ASE) of the group shall not exceed ±25m (±80 ft); and

(b) The sum of the absolute value of the mean ASE for the group and three standard deviations of ASE within the group shall not exceed 75 m (245 ft); and

(c) Errors in altitude keeping shall be symmetric about a mean of 0 m (0 ft) and shall have a standard deviation not greater than 13 m (43 ft) and should be such that the error frequency decreases with increasing error magnitude at a rate which is at least exponential.'

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

procedures covering the means for ensuring that in-service degradation is controlled at an acceptable level.

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

(a) 'the mean uncorrected residual position error (static source error) of the group shall not exceed ±25 m (±80 ft); and

(b) the sum of the absolute value of the mean ASE for the group and three standard deviations of ASE within the group, shall not exceed 60 m (200 ft); and

(c) each individual aircraft in the group shall be built to have ASE contained within ±60 m (±200 ft); and

(d) an automatic altitude control system shall be required and will be capable of controlling altitude within a tolerance band of ±15 m (±50 ft) about selected altitude when operated in the altitude hold mode in straight and level flight under non-turbulent, non-gust conditions.'

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

APPENDIX 6 - SPECIFIC PROCEDURES FOR EUROPEAN RVSM AIRSPACE

1 INTRODUCTION

1.1 This Appendix is included for information. It states the procedures that were approved by the EUROCONTROL Airspace and Navigation Team in February 1998.

1.2 The area of applicability will be defined in an amendment to ICAO document 7030 which is expected to be approved in 1998. This appendix will be updated as required in a later issue of this Temporary Guidance Leaflet to take account of the amended ICAO document 7030.

2 DEFINITIONS

For the purposes of these procedures, the following terms will have the following meanings:

Flight Level Allocation Scheme (FLAS):

The scheme whereby specific flight levels may be assigned to specific route segments within the route network

RVSM (Operational) Approval:

The approval that is issued for each individual aircraft by the appropriate State authority once an operator has achieved the following:

I. RVSM Airworthiness approval; and
II. State Approval of operations manual (where applicable) and on-going maintenance procedures.

Strategic Flight Level:

A flight level which is flight-plannable in accordance with the Table of Cruising Levels of ICAO Annex 2, Appendix 3 (see Attachment A) and the Flight Level Allocation Scheme (FLAS), as specified in the relevant Aeronautical Information Publications.

Tactical Flight Level:

A flight level which is not flight-plannable and which is reserved for tactical use by ATC.

3 AREA OF APPLICABILITY

3.1 Except for State aircraft operating as Operational Air Traffic (OAT), and as per the provisions of ICAO Annex 2, Appendix 3, only flight operations conducted under IFR shall be permitted in the RVSM airspace.

3.2 The RVSM procedures shall apply to operations between FL 290 and FL 410 inclusive in the Flight Information Regions/Upper Information Regions (FIRs/UIRs)as defined in ICAO doc 7030.

3.3 Provisions for the transition of aircraft, including the accommodation of civil aircraft non-RVSM approved within RVSM airspace for the purpose of clearing aircraft to flight levels appropriate to the adjacent operating environment, shall be applicable in the FIRs/UIRs as defined in ICAO doc 7030.

4 PROCEDURES

The ATC procedures related to RVSM include the following:

- General Procedures
- Procedures for non-RVSM approved State Aircraft operating as General Air Traffic (GAT) within the RVSM airspace
- Procedures for State Aircraft Operating as OAT, Crossing ATS Routes, within the RVSM Airspace
- Procedures relative to Airspace Restrictions and Reservations
- Flight planning procedures
- Inter-centre co-ordination procedures
- Contingency procedures
- Transition procedures
- Phraseology

5 GENERAL PROCEDURES.

5.1 ATC shall only clear RVSM approved aircraft into the RVSM airspace, except for State aircraft and except as provided for in paragraph 11.

Note: See Paragraph 12 for applicable controller-pilot RTF.

5.2 ATC shall provide a minimum of 300m (1,000 ft) vertical separation between RVSM approved aircraft operating within the RVSM airspace.

5.3 ATC shall provide a minimum of 600m (2,000 ft) vertical separation between any non-RVSM approved State aircraft and any other aircraft operating within the RVSM airspace.

5.4 In airspace where transition tasks are carried out (sub-paragraph 3.3 above refers), ATC shall provide a minimum of 600m (2,000 ft) vertical separation between any non-RVSM approved aircraft and any other aircraft.

5.5 ATC shall withhold clearance into the RVSM airspace for all formation flights involving civil aircraft.

5.6 ATC shall provide a minimum of 600m (2,000 ft) vertical separation between all formation flights involving State aircraft and any other aircraft operating within the RVSM airspace.

5.7 ATC shall assign flight levels to non-RVSM approved aircraft, other than State aircraft, in accordance with the table below:

	Landing aerodrome within lateral limits of RVSM airspace	Landing aerodrome outside lateral limits of RVSM airspace
Departing aerodrome within lateral limits of RVSM airspace	Assign level **below** RVSM airspace	Assign level **below** RVSM airspace
Departing aerodrome outside lateral limits of RVSM airspace	Assign level **below** RVSM airspace	Assign level **below or above** RVSM airspace

6 PROCEDURES FOR STATE AIRCRAFT OPERATING AS OPERATIONAL AIR TRAFFIC (OAT), CROSSING ATS ROUTES, WITHIN THE RVSM AIRSPACE.

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

6.2 The minimum vertical separation required between (a) State aircraft operating as OAT, crossing ATS routes, and (an) aircraft operating as GAT, where both are operating within the RVSM airspace, shall be 600m (2,000 ft).

6.3 However, in an airspace environment where both the civil and military ATC units are fully aware as to the RVSM approval status of all traffic involved, a reduced vertical separation of 300m (1,000 ft) can be applied between a RVSM approved State aircraft operating as OAT, and RVSM approved GAT.

7 PROCEDURES RELATIVE TO AIRSPACE RESTRICTIONS AND /OR RESERVATIONS

Note: The procedures specified in this paragraph 7 are subject to further review by the EUROCONTROL Airspace and Navigation Team after the implementation of a common methodology of delineation, publication and use of restricted and/or reserved airspace.

7.1 Unless an appropriate horizontal spacing exists:

7.1.1 ATC shall provide a minimum 600m (2,000 ft) vertical spacing below the published lower limit of an airspace restriction and/or reservation with a published lower limit of FL 300 or above and aircraft operating within the vertical limits of the RVSM airspace so as to ensure that vertical separation minima are not infringed.

7.1.2 ATC shall provide a minimum 600m (2,000 ft) vertical spacing above the published upper limit of an airspace restriction and/or reservation and aircraft operating within the vertical limits of the RVSM airspace so as to ensure that vertical separation minima are not infringed.

7.2 Consequently:

7.2.1 The first flight level usable by ATC below an airspace restriction and/or reservation shall be 600m (2,000 ft) below the published lower limit of such airspace, where the published lower limit is FL 300 or above.

7.2.2 The first flight level usable by ATC above an airspace restriction and/or reservation shall be 600m (2,000 ft) above the published upper limit of such airspace, where the published upper limit is FL 290 or above.

8 FLIGHT PLANNING

8.1 The flight plan submitted for a flight intending to operate across the lateral limits of the RVSM airspace shall include:

- the specific requested flight level for that portion of the route commencing immediately after the entry point at the lateral limits of the RVSM airspace, consistent with the FLAS, if published;
- the specific requested flight level for that portion of the route commencing immediately after the exit point at the lateral limits of the RVSM airspace, consistent with the FLAS, if published.

8.2 All operators of RVSM approved aircraft, shall insert the letter "**W"** in Item 10 of the ICAO Flight Plan, regardless of the requested flight level.
Note: to be included in the flight planning section of Doc. 7030.

8.3 All operators of non-RVSM approved State aircraft with a requested flight level of FL 290 or above, shall insert the phrase "**STS/NONRVSM"** in Item 18 of the ICAO Flight Plan.

8.4 Operators of customs or police aircraft shall insert the letter "**M**" in Item 8 of the ICAO Flight Plan if non-RVSM approved and intending to operate within the RVSM airspace.

8.5 All operators filing repetitive flight plans (RPLs) shall include in Item Q equipment information in regards to their RVSM approval status in the format **"EQPT/W",** for flights RVSM approved and **"EQPT/ ",** for flights non RVSM approved with operational service ceilings corresponding to FL 250 regardless of the requested flight level.

Note: the ability to address Item Q with equipment information is to be confirmed as policy.

8.6 Operators of State aircraft, not RVSM approved, filing repetitive flight plans including a requested Flight Level of FL 290 or above, shall include **"STS/NONRVSM"** in Item Q.

Note: The ability to address Item Q with equipment information is to be confirmed as policy.

8.7 Regardless of the RVSM approval status of the individual aircraft concerned, the letter "**W**" shall never be inserted in Item 10 of flight plans related to formation flights involving State aircraft.

8.8 Operators of formation flights involving State aircraft intending to operate as General Air Traffic (GAT) in RVSM airspace shall include **"STS/NONRVSM"** in Item 18 of the ICAO Flight Plan.

9 INTER-CENTRE CO-ORDINATION

9.1 The On-line Data Exchange System should support the co-ordination of requests for special handling (e.g.: STS) as filed in Item 18 of the ICAO Flight Plan.

9.2 Computer Assisted Co-ordination of Estimate Messages.

In the case of automated messages not containing the information provided in Item 18 of the flight plan relating to RVSM operations, the sending air traffic control unit shall inform the receiving air traffic control unit of that information by verbally supplementing the activation message.

Note: See paragraph 12 below for details of the precise RTF to be used.

9.3 Verbal Co-ordination of Estimate Messages

When a verbal co-ordination process is being used, the sending air traffic control unit shall include the information filed in Item 18 of the ICAO flight plan, relevant to RVSM operations, at the end of the verbal estimate message.

Note: See paragraph 12 for details of the precise RTF to be used.

9.4 For the case of a single aircraft experiencing an in flight contingency, the associated co-ordination messages shall be supplemented verbally by a description of the cause of the contingency.

Note: See paragraph 12 for details of the precise RTF to be used.

10 CONTINGENCY PROCEDURES

Note: See paragraph 12 for details of the precise co-ordination RTF to be used.

10.1 Procedures applicable to individual aircraft.

Equipment related:

10.1.1 Where an aircraft's Mode C displayed level indicates a deviation from the cleared flight level of 90m (300 ft). or more, the controller shall inform the pilot as soon as practicable and the pilot shall return to his cleared flight level immediately.

10.1.2 When informed by the pilot that the aircraft's equipment has degraded to below altimetry MASPS compliance levels while operating within the RVSM airspace, the controller shall provide for either a minimum vertical separation of 600m (2,000 ft) or an appropriate horizontal separation. Controllers shall normally clear the aircraft below FL 290 before the next inter-centre transfer of control point, unless otherwise co-ordinated.

Weather related:

10.1.3 For the case of an individual aircraft reporting severe turbulence, the controller shall provide for either an appropriate horizontal separation, or an increased vertical separation.

10.1.4 If informed of the existence of severe turbulence, the controller shall solicit other relevant turbulence reports to determine, in co-ordination with the Supervisor, whether RVSM operations should be suspended entirely or within a specific level band and/or area.

10.2 Procedures for multiple aircraft.

Weather related, non-predicted:

10.2.1 For the case of immediate requirements where a controller has received no advance warning of impending meteorological conditions that could create severe turbulence, the controller shall provide for an increased minimum vertical separation or an appropriate horizontal separation, and the following, although not exhaustive, should be considered:

- Since each real time situation will demand very specific, distinct actions, the controller should use his/her best judgement to ensure the safety of the aircraft under his/her responsibility.
- The controller should pass traffic information to the extent possible.
- The controller will co-ordinate with the Supervisor for the purpose of determining whether RVSM operations will be suspended entirely or within a specific level band and/or area.
- If a reversion to Conventional Vertical Separation Minima is deemed necessary, co-ordination with adjacent ACCs shall be accomplished to ensure an orderly progression to the transfer of traffic under Conventional Vertical Separation Minima conditions.
- Supervisors may co-ordinate, to the extent deemed necessary, a request for the deactivation of any airspace restrictions and/or reservations required to provide additional radar vectoring airspace necessary to facilitate the transition to Conventional Vertical Separation Minima.
- The Supervisor should co-ordinate with the parent flow management position to adjust the applicable sector capacities.

Weather related, predicted:

10.2.2 For the case of meteorological conditions causing severe turbulence, predicted by Meteorological Services, the procedures required will of consequence be of a strategic nature. A meteorological forecast, predicting severe turbulence, received by an ACC, will demand of the Supervisor a decision as to whether RVSM operations are to be interrupted, for what period of time, and for what specific level(s) and/or area. Should an increased vertical separation be necessary, the Supervisor will co-ordinate with the adjacent ACCs concerned as to the flight levels appropriate for the transfer of traffic, unless a contingency FLAS has been determined in the Letter of Agreement. The Supervisor should co-ordinate with the parent flow management position to establish the applicable sector capacities. The issuance of a NOTAM should be considered as circumstances require.

11 TRANSITION PROCEDURES

11.1 For aircraft to be transferred from RVSM airspace to non-RVSM airspace, the last area control centre providing air traffic control service to such aircraft shall establish a minimum of 600m (2,000 ft) vertical separation before the aircraft passes the transfer of control point to the adjacent area control centre established at a flight level in accordance with the ICAO

Table of Cruising Levels as published in ICAO Annex 2, Appendix 3, table b), and/or in accordance with the FLAS, if applicable, and/or as specified in the inter-centre Letter of Agreement.

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11.2 For aircraft transferred from non-RVSM airspace to RVSM airspace, the first area control centre providing air traffic control service to such aircraft shall ensure that RVSM approved aircraft and non-RVSM approved State aircraft are cleared so as to be established at a flight level in accordance with the ICAO Table of Cruising Levels as published in ICAO Annex 2, Appendix 3, table a), and/or in accordance with the FLAS, if applicable and/or as specified in the inter-centre Letter of Agreement, before the aircraft passes the transfer of control point to the adjacent ACC.

11.3 For aircraft landing at an aerodrome within the lateral limits of the RVSM airspace, the first area control centre providing air traffic control to aircraft transferred to RVSM airspace from non-RVSM airspace shall ensure that non-RVSM approved aircraft, except State aircraft, are cleared so as to be established at a flight level below FL 290 in accordance with the FLAS, if applicable and/or as specified in the inter-centre Letter of Agreement, before the aircraft passes the transfer of control point to the adjacent ACC.

11.4 For aircraft landing at an aerodrome outside and transiting the lateral limits of the RVSM airspace, the first area control centre providing air traffic control to aircraft transferred to RVSM airspace from non-RVSM airspace shall ensure that non-RVSM approved aircraft, except State aircraft, are cleared so as to be established at a flight level below FL 290 or above FL 410 before the aircraft passes the transfer of control point to the adjacent area control centre in accordance with the FLAS, if applicable and/or as specified in the inter-centre Letter of Agreement.

12 PHRASEOLOGY

12.1 Controller-pilot RTF: (* *indicates a pilot transmission)*

Paragraph	Message	Phraseology
12.1.1	To ascertain the RVSM approval status of a flight:	*(callsign)* **CONFIRM RVSM APPROVED**
12.1.2	Pilot indication of non-RVSM approval status: To be stated: I. in the initial call on any frequency within the RVSM airspace (*controllers shall provide a readback with this same phrase)*, and II. in all requests for flight level changes pertaining to flight levels within the RVSM airspace III. in all readbacks to flight level clearances pertaining to flight levels within the RVSM airspace As well, pilots of aircraft, other than State aircraft, shall respond to level clearances involving the vertical transit through either FL 290 or FL 410 with this phrase.	**NEGATIVE RVSM ***

Paragraph	Message	Phraseology
12.1.3	State aircraft, not RVSM approved, shall indicate their status as being that of a State aircraft, in conjunction with a negative response to the RTF indicated in sub-paragraph. 12.1.1, with the phrase:	**NEGATIVE RVSM STATE AIRCRAFT***
12.1.4	Denial of clearance into the RVSM airspace:	*(callsign)* **UNABLE CLEARANCE INTO RVSM AIRSPACAsia PacificE, MAINTAIN [***or* **DESCEND TO,** *or* **CLIMB TO] FLIGHT LEVEL** *(number)*
12.1.5	For the case of an individual aircraft reporting severe turbulence or other severe weather related phenomenon, the pilot phraseology shall be:	**UNABLE RVSM DUE TURBULENCE***
12.1.6	The phraseology required of a pilot to communicate those circumstances which would cause an aircraft's equipment to degrade to below altimetry MASPS compliance levels shall be: The phrase is to be used to convey both the initial indication of the non-altimetry MASPS compliance and, henceforth, on initial contact on all frequencies within the RVSM airspace until such time as the problem ceases to exist. The phrase is to be used to convey both the initial indication of the non-altimetry MASPS compliance and, henceforth, on initial contact on all frequencies within the lateral limits of the RVSM airspace.	**UNABLE RVSM DUE EQUIPMENT***
12.1.7	The pilot shall communicate his/her ability to resume operation within the RVSM airspace after an equipment related contingency, or his/her ability to resume RVSM operations after a weather related contingency with the phrase:	**READY TO RESUME RVSM***
12.1.8	Controllers wishing to solicit this information shall use the phrase:	**REPORT ABLE TO RESUME RVSM**

12.2 Co-ordination between ATS units:

Paragraph	Message	Phraseology
12.2.1	To verbally supplement an automated estimate message exchange which does not automatically transfer Item 18 information:	**NEGATIVE RVSM**

12.2.2	To verbally supplement estimate messages of flights non-RVSM approved:	**NEGATIVE RVSM**
12.2.3	To communicate the cause of a single aircraft contingency:	**UNABLE RVSM DUE TURBULENCE [***or* **EQUIPMENT,** *as applicable***]**

APPENDIX 7 - SPECIFIC PROCEDURES FOR THE NORTH ATLANTIC AIRSPACE

1. INTRODUCTION

1.1 North Atlantic Minimum Navigation Performance Specification (NAT MNPS) airspace is the area where RVSM has been first implemented. The guidance that follows should be applied when RVSM is in use in NAT MNPS airspace.

1.2 This Appendix contains information on procedures that are unique to North Atlantic RVSM airspace. Contingency procedures contained in Regional Supplementary Procedures and guidance specifically related to RVSM are presented in this appendix. Contingencies that relate to lateral as well as vertical navigation are discussed.

2. GENERAL INFORMATION: AIRSPACE DIMENSIONS

2.1 Entry into NAT RVSM airspace requires the holding approvals for both lateral navigation and height keeping performance.

2.2 NAT MNPS airspace has a ceiling of FL 420 and a base of FL 285 with 300m (1,000 ft) vertical separation applied to aircraft operating at and between FL 290 and FL 410.

3. INTENDED USE OF THIS APPENDIX MATERIAL

3.1 Paragraph 4, Basic Concepts for Contingencies

This paragraph provides an overview of contingency procedures. It is intended to direct the pilot's thinking to the concepts involved and aid in understanding the specific guidance detailed in paragraphs 5 and 6. This material should be included in training programmes and appropriate operations manuals.

3.2 Paragraph 5, Guidance to the Pilot in the Event of Equipment Failures or Encounters with Turbulence after Entering NAT MNPS Airspace

This paragraph details guidance on specific actions for the pilot to take in the situations listed. The pilot actions should be considered required pilot knowledge and should be included in training/qualification programmes and appropriate operations manuals.

3.3 Paragraph 6 and Supplement, Doc. 7030 North Atlantic Contingency Procedures

In this paragraph and the Supplement to this Appendix, North Atlantic Regional Supplementary Procedures (Doc 7030) paragraph 6, Special Procedures for In-flight Contingencies (applicable when RVSM is implemented) are reprinted for ease of reference. Doc. 7030 paragraph 6 gives guidance on actions to be taken by the pilot. Pilot actions should be considered required pilot knowledge. The material may be condensed for ease of presentation and should be included in training/qualification programmes and appropriate operations manuals.

3.4 Paragraphs 7 and 8

Paragraph 7 discusses RVSM transition areas. Paragraph 8 is a general discussion of pilot action in relation to the proposed RVSM monitoring system. These paragraphs should be covered in training programmes and operations manuals.

3.5 Paragraph 9 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 programmes as an operator considers necessary.

4. BASIC CONCEPTS FOR CONTINGENCIES

4.1 General

The NAT Regional Supplementary Procedures document (Doc. 7030) were revised to provide for RVSM implementation in NAT MNPS airspace. The North Atlantic Systems Planning Group developed draft paragraph 6 revisions that were endorsed by the Limited NAT Regional Air Navigation Meeting in November 1992. They have been made effective at the start of operational trials which commenced on 27 March 1997. The NAT MNPS Operations Manual has been revised with this material.

4.2 The basic concepts for contingencies, described in this paragraph, have been developed from the specific guidance contained in Doc. 7030 paragraph 6 reprinted in the Supplement to this Appendix. Contingency procedures are 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 Doc. 7030.

4.3 The basic concepts for contingencies are:

4.3.1 *Pilot in Command Responsibility* 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 aircraft.

4.3.2 If the pilot is unsure of the vertical or lateral position of the aircraft or the aircraft deviates intentionally from its assigned flight level or track, without prior ATC clearance, then the pilot will need to take action to mitigate the potential for collision with aircraft on adjacent routes or flight levels.

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, or 131.8 MHz as a back-up frequency.

4.3.3 Unless the nature of the contingency dictates otherwise, the pilot should advise ATC as soon as possible of the problem and request an ATC clearance before deviating from the assigned route or flight level.

4.3.4 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 a flight level and/or on a track where other aircraft are least likely to be encountered.

This can be accomplished by off-setting the aircraft from routes or flight levels normally flown in the airspace. Doc. 7030 paragraph 6 provides recommendations on the preference for the pilot's following actions:

(a) Offsetting half the lateral distance between routes or tracks, or

(b) Offsetting half the vertical distance between flight level normally flown.

(c) Descending below FL 285 or climbing above FL 410. Flight flown at these levels limits the possibility of conflict with other aircraft.

4.3.5 When executing a contingency manoeuvre the pilot should:

(a) Watch for conflicting traffic.

(b) Continue to alert other aircraft using 121.5 MHz or 131.8 MHz and aircraft lights.

(c) Continue to fly tracks or flight levels which are likely to be unoccupied.

(d) 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 NAT MNPS AIRSPACE

5.1 In addition to emergencies that require immediate descent, such as loss of thrust or pressurisation, ATC should be made aware of conditions that may make it impossible for an aircraft to maintain its cleared flight level appropriate to RVSM. Controllers will react to such conditions but these actions cannot be specified, as they will depend upon the situation at the time.

5.2 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 recognised that the pilot and controller will use judgement to determine the action most appropriate to any given situation. The guidance material recognises that for certain equipment failures, the safest course of action may be for the aircraft to continue in MNPS airspace while the pilot and controller take precautionary action to protect separation. For extreme cases of equipment failure, however, the guidance recognises that the safest course of action may be for the aircraft to leave MNPS airspace by obtaining a revised ATC clearance or if unable to obtain prior ATC clearance, executing the established contingency manoeuvre to leave the assigned route or track.

Note: Paragraph 9 gives an expanded description of the scenarios listed below:

5.3 Contingency Scenario

The pilot is unsure of the vertical position of the aircraft due to loss or degradation of all primary altimetry systems or is unsure of the capability to maintain cleared flight level due to turbulence or loss of all automatic altitude control systems.

5.3.1 *Pilot Actions* The pilot should maintain cleared flight level while evaluating the situation and:

(a) Watch for conflicting traffic

(b) If considered necessary, alert nearby aircraft by:

(i) Making maximum use of exterior lights;

(ii) Broadcasting position, flight level, and immediate intentions on 121.5 MHz or 131.8 MHz as a back up.

(c) Notify ATC of the situation and the intended course of action. Possible courses of action include:

(i) Continuing in MNPS airspace provided that the aircraft can maintain the cleared flight level.

(ii) Requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft cannot maintain the cleared flight level and ATC cannot establish adequate separation from other aircraft.

(iii) Executing the Doc. 7030 contingency manoeuvre to leave the assigned track if prior ATC clearance cannot be obtained and the aircraft cannot maintain cleared flight level.

5.3.2 *Expected ATC actions* The following information is provided for information purposes. ATC can be expected to:

(a) Obtain the pilot's intentions;

(b) If the pilot intends to continue in MNPS airspace, consider establishing increased vertical, longitudinal, or lateral separation;

(c) Pass traffic information;

(d) If the pilot requests clearance to exit MNPS airspace, accommodate expeditiously, if possible;

(e) If adequate separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit MNPS airspace, ATC can be expected to notify other aircraft nearby and continue to monitor the situation.

(f) Advise adjoining ATC facilities/sectors of the situation.

5.4 Contingency Scenario

Failure or loss of accuracy of one primary altimetry system; for example, 60m (200 ft) or more difference between primary altimeters.

5.4.1 *Pilots Actions* 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 the actions stated in the preceding scenario.

6. DOC 7030 NORTH ATLANTIC CONTINGENCY PROCEDURE

The revised contingency procedures for RVSM are reprinted in a supplement to this Appendix 7 for ease of reference. However, Doc. 7030 is the source document for NAT contingency procedures. Doc. 7030 and the North Atlantic MNPS Airspace Operations Manual should be consulted before preparing training material.

7. TRANSPONDER FAILURE AND RVSM TRANSITION AREAS

The specific actions taken by ATC in the event an aircraft's transponder failure in an RVSM transition area will be determined by the provider States.

Note: Transition areas have been implemented where different separation standards exist between adjacent airspace.

8. HEIGHT MONITORING

A height-monitoring system is an element of the RVSM implementation programme for the NAT with regional procedures for its use.

9. EXPANDED GUIDANCE FOR RVSM EQUIPMENT FAILURE AND TURBULENCE SCENARIOS

The scenarios given below expand upon the basic concepts given in paragraph 5. They may be used as the basis for training programmes.

<u>9.1 Scenario: All automatic altitude control systems fail (e.g. automatic altitude hold)</u>

9.1.1 *Initial actions* The pilot should:

(a) Maintain cleared flight level

(b) Evaluate the aircraft's capability to maintain flight level through manual control.

9.1.2 *Subsequent actions* The pilot should:

(a) Watch for conflicting traffic;

(b) If considered necessary, alert nearby aircraft by;

(i) Making maximum use of exterior lights:

(ii) Broadcasting position, flight level and immediate intentions on 121.5 MHz.(131.8 MHz may be used as a back-up);

(c) Notify ATC of the failure and the intended course of action. Possible courses of action include:

(i) Continuing in MNPS airspace provided that the aircraft can maintain the cleared flight level.

(ii) Requesting ATC clearance to climb above or descend below RVSM airspace if the aircraft cannot maintain flight level and ATC cannot establish increased vertical, longitudinal, or lateral separation.

(d) Executing the Doc. 7030 contingency manoeuvre to leave the assigned route or track if prior ATC clearance cannot be obtained and the aircraft cannot maintain level.

9.1.3 *Expected ATC actions* ATC can be expected to:

(a) Obtain the pilot's intentions.

(b) If the pilot intends to continue in MNPS airspace, consider establishing increased vertical, longitudinal, or lateral separation.

(c) Pass traffic information.

(d) If the pilot requests clearance to exit RVSM airspace, accommodate expeditiously, if possible.

(e) If increased vertical, longitudinal, or lateral separation cannot be established and it is not possible to comply with the pilot's request for clearance to exit RVSM airspace, ATC can be expected to notify other aircraft nearby and continue to monitor the situation. In this situation, the pilot may be executing his authority to protect the safety of the aircraft by flying the established contingency procedures to leave the assigned route or track.

(f) Advise adjoining ATC facilities/sectors of the situation.

9.2 Scenario: Loss of redundancy in primary altimetry systems

9.2.1 *Course of action* The pilot should take the following action:

If the remaining altimetry system is functioning normally, couple that system, where possible, to the automatic altitude control system, notify ATC of the loss of redundancy and maintain vigilance of altitude keeping.

9.2.2 *Expected ATC actions* ATC can be expected to acknowledge the situation and continue to monitor progress.

9.3 Scenario: All primary altimetry systems fail or are considered unreliable

9.3.1 *Initial actions* The pilot should:

(a) Maintain altitude by reference to the standby altimeter (if the aircraft is so equipped);

(b) Alert nearby aircraft by:

(i) Making maximum use of exterior lights; and

(ii) Broadcasting position, flight level and intentions on 121.5 MHz (131.8 MHz can be used as a back-up).

(c) Notify ATC of the inability to meet MNPS performance requirements, consider declaring an emergency, and request clearance to exit MNPS airspace.

9.3.2 *Subsequent actions* The pilot should:

(a) If unable to obtain ATC clearance, in a timely manner, execute Doc. 7030 contingency procedures to leave the assigned route or track and descend below RVSM airspace (if operationally feasible).

(b) If it is not operationally feasible to execute Doc. 7030 contingency procedures, continue to alert nearby aircraft and co-ordinate with ATC.

9.3.3 *Expected ATC actions* ATC can be expected to:

(a) When notified by the pilot that the aircraft cannot meet MNPS performance requirements, ATC can be expected to accommodate the request for clearance to exit the airspace in an expeditious manner.

(b) If unable to accommodate the request for clearance to exit the airspace, ATC should request the pilot's intentions, advise the pilot of traffic in the proximity, advise other aircraft and continue to monitor the situation.

9.4 Scenario: Primary altimeters diverge by more than ±60 m (±200 ft)

9.4.1 *Course of action* The pilot should:

(a) 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)

(b) If the defective system can be determined, couple the functioning altimetry system to the altitude keeping device.

(c) If the altimeter displays differ by more than ±60 m (±200 ft) and it cannot be determined which system is defective, follow the guidance in sub-paragraph 9.1(c) for failure or unreliable altimeter indications of all primary altimeters.

9.5 Scenario: Aircraft encounters turbulence greater than moderate, which the pilot believes will affect the aircraft's capability to maintain flight level

9.5.1 *Course of action* The pilot should:

(a) Watch for conflicting traffic and make maximum use of exterior lights.

(b) Broadcast call sign, position, flight level, nature and severity of turbulence, and intentions on 121.5 MHz (131.8 MHz may be used as a back-up).

(c) Notify ATC as soon as possible and request flight level change if necessary.

(d) If the aircraft cannot maintain level, execute Doc. 7030 contingency procedures to leave the assigned route or track.

9.5.2 *Expected ATC actions* ATC can be expected to:

(a) If possible, establish increased vertical, longitudinal, or lateral separation.

(b) Accommodate the request for change in flight level, if possible.

(c) If neither of the above actions are possible, notify other aircraft in the vicinity and monitor the situation.

(d) Consider suspending RVSM operations in the affected area.

SUPPLEMENT TO APPENDIX 7 - SPECIAL PROCEDURES FOR IN-FLIGHT CONTINGENCIES

Extract from ICAO DOC 7030 Regional Supplementary Procedures, Part 1 RULES OF THE AIR, AIR TRAFFIC SERVICES AND SEARCH AND RESCUE (revised 5 February 1997)

6 SPECIAL PROCEDURES FOR IN-FLIGHT CONTINGENCIES
(P-RAC, Part II-16)

6.1 The following procedures are intended for guidance only. Although all possible contingencies cannot be covered, they provide for the more frequent cases of:

1) inability to maintain assigned level due to weather, aircraft performance, pressurisation failure and problems associated with high level supersonic flight;
2) loss of, or significant reduction in, the navigation capability when operating in parts of the airspace where high accuracy of navigation is a prerequisite to the safe conduct of flight operations; and
3) en route diversion across the prevailing NAT traffic flow.

With regard to 1) and 3) above, the procedures are applicable primarily when rapid descent and/or turn-back or diversion is required. The pilot's judgement shall determine the sequence of actions taken, and air traffic control shall render all possible assistance having regard to the specific circumstances.

6.2 General Procedures

The following general procedures apply to both subsonic and supersonic aircraft.

6.2.1 If an aircraft is unable to continue flight in accordance with its air traffic control clearance, a revised clearance shall, whenever possible, be obtained prior to initiating any action. This shall also apply to aircraft which are unable to maintain an accuracy of navigation on which the safety of the separation minima applied by air traffic control between it and adjacent aircraft depends. This shall be accomplished using the radiotelephony distress or urgency signal as appropriate. Subsequent air traffic control action with respect to that aircraft shall be based on the intentions of the pilot and the overall air traffic situation.

6.2.2 If prior clearance cannot be obtained, an air traffic control clearance shall be obtained at the earliest possible time and, in the meantime, the pilot shall:

1) broadcast position (including the ATS route designator or the track code, as appropriate) and intentions on frequency 121.5 MHz at suitable intervals until air traffic control clearance is received;
2) make maximum use of aircraft lights to make the aircraft visible;
3) maintain a watch for conflicting traffic; and
4) initiate such action as necessary to ensure safety of the aircraft.

6.3 Special contingency procedures for subsonic aircraft

6.3.1 The following guidance is recommended for aircraft operating within North Atlantic airspace.

6.3.2 Initial action

6.3.2.1 If unable to comply with the provision of 6.2.1 to obtain prior air traffic control clearance, the aircraft should leave its assigned route or track by turning 90 degrees to the right or left whenever this is possible. The direction of the turn should, where possible, be determined by the position of the aircraft relative to any organized route or track system (e.g. whether the aircraft is outside, at the edge of, or within the system). Other factors which may affect the direction of the turn are the direction of an alternate airport, terrain clearance and the levels allocated to adjacent routes or tracks.

6.3.3 Subsequent action

6.3.3.1 An aircraft able to maintain its assigned flight level should:

1) turn to acquire and maintain in either direction a track laterally separated by 30 NM from its assigned route or track; and
2) if above FL 410, climb or descend 300m (1,000 ft); or
3) if below FL 410, climb or descend 150m (500 ft); or
4) if at FL 410, climb 300 m (1,000 ft) or descend 150 m (500 ft).

6.3.3.2 An aircraft not able to maintain its assigned flight level should:

1) initially minimise its descent rate to the extent that it is operationally feasible;
2) turn while descending to acquire and maintain in either direction a track laterally separated by 30 NM from its assigned route or track; and
3) for the subsequent level flight, a level should be selected which differs from those normally used by 300 m (1,000 ft) if above FL 410 or by 150 m (500 ft) if below FL 410.

6.3.4 En route diversion across the prevailing NAT air traffic flow

6.3.4.1 The guidance in sub-paragraph 6.3.4.3 applies to aircraft that:

1) are operating within the OTS or on random routes that are proximate to the OTS; and
2) can climb or descend to an altitude above or below those where the majority of NAT aircraft operate.

Sub-paragraph 6.3.4.4 contains guidance for other situations where diversion across adjacent tracks or routes is necessary.

6.3.4.2 The basic concept of this guidance is that, when operationally feasible, before diverting across tracks or routes with heavy traffic, the aircraft should offset from the assigned track or route by 30 NM and expedite a descent to an altitude below or a climb to an altitude above those where the vast majority of NAT aircraft operate before proceeding toward the alternate aerodrome. Flight below FL 285 or above FL 410 should meet this objective.

6.3.4.3 In the event of a contingency which necessitates an en route diversion to an alternate aerodrome, across the direction of the prevailing NAT traffic flow, and prior ATC clearance cannot be obtained:

6.3.4.3.1 An aircraft able to maintain its assigned flight level should:

1) turn toward the alternate aerodrome to acquire a track which is separated laterally by 30 NM from the assigned route or track; and
2) if above FL 410, climb or descend 300 m (1,000 ft); or
3) if below FL 410, climb or descend 150 m (500 ft); or
4) if at FL 410, climb 300 m (1,000 ft) or descend 150m (500 ft); and
5) fly the offset track while expediting its descent to an altitude below FL 285 or a climb to an altitude above FL 410; and
6) when below FL 285 or above FL 410, proceed towards the alternate aerodrome while maintaining a level which differs from those normally used by 150 m (500 ft) if below FL 410 or 300 m (1,000 ft) if above FL 410; or
7) if unable or unwilling to make a major climb or descent, fly an altitude offset for the diversion until obtaining an ATC clearance. See sub-paragraph 6.3.4.4 below.

6.3.4.3.2 An aircraft not able to maintain its assigned flight level should:

1) initially minimise its descent rate to the extent it is operationally feasible; and
2) start its descent while turning to acquire a track separated laterally by 30 NM from its assigned route or track; and
3) unless the nature of the contingency dictates otherwise, maintain the offset track while expediting its descent to an altitude below FL 285; and
4) unless the nature of the contingency dictates otherwise, when below FL 285, it should proceed towards the alternate aerodrome; and
5) continue descent to a level which can be maintained and which differs from those normally used by 150 m (500 ft) if below FL 410.

6.3.4.3.3 If these contingency procedures are employed by a twin-engine aircraft as a result of a shutdown of a power unit or a primary aeroplane system failure, the pilot should so advise ATC as soon as practicable, reminding ATC of the type of aircraft involved and requesting expeditious handling.

6.3.4.4 Aircraft which are required to divert across the prevailing NAT air traffic flow and are:

1) unable or unwilling to descend to an altitude below those where the majority of NAT aircraft operate due to operational constraints; or
2) unsure of their proximity to other routes or tracks; or
3) assigned to a route which crosses the OTS at a significant angle;

should execute the actions specified in sub-paragraphs 6.3.4.4.1 or 6.3.4.4.2 below.

6.3.4.4.1 An aircraft which is able to maintain its assigned flight level should:

1) if above FL 410, climb or descend 300 m (1,000 ft); or
2) if below FL 410, climb or descend 150 m (500 ft); or
3) if at FL 410, climb 300 m (1,000 ft) or descend 150 m (500 ft)

while turning to proceed toward the alternate aerodrome.

6.3.4.4.2 An aircraft which is unable to maintain its assigned flight level should:

1) expedite a descent to an altitude below those where the majority of NAT aircraft operate while turning toward the alternate aerodrome; and
2) diligently follow the guidance in sub-paragraph 6.2.2 above in regard to radio calls, aircraft lights and watching for conflicting traffic.

APPENDIX F   Example Operator Application for Approval To Conduct Operations in Airspace Where RVSM Is Applied

This Appendix provides an EXAMPLE of an operator application for authority to conduct RVSM operations. It shows a suggested format and content for such an application.

This information is provided for *EXAMPLE* purposes only!
Other States may have different requirements.

This material has been reviewed by the Technical Programs And Aircraft Maintenance Divisions at FAA Headquarters in Washington. It is believed that this material provides a useful aid for operators preparing material to submit to FAA Flight Standards District Offices (FSDO) and Certificate Holding District Offices (CHDO).

It is assumed that each operator will review the applicable paragraphs in FAA Interim Guidance On The Approval Of Operators/Aircraft For RVSM Operations (91-RVSM found at Appendix A to this document), and provide information pertinent to the specific aircraft type or group for which it intends to seek approval and to the operator's individual operations and maintenance programs.

Additional information is available on the RVSM website:

www.faa.gov/ats/ato/rvsm1.htm
OR
www.faa.gov , QUICK JUMP MENU, RVSM, GO

For questions or revisions to this material, please contact one of the following:

Roy Grimes (FAA HQ, AFS-400)
Ph. 202-267-3734;   Fax 202-267-5086;   E-Mail: roy.grimes@faa.gov

Bob Hanson (FAA HQ, AFS-430)
Ph 202-267-3739;   Fax 202-267-5086;   E-Mail: robert.g.hanson@faa.gov

Bob Miller (FAA/CSSI Inc.)
Ph: 202-484-3359,   Fax 202-863-2398,   E-Mail: rmiller@cssiinc.com

Additional References:

1. PILOT TRAINING RELATED TO TCAS OPERATION IN RVSM. The FAA has developed coordinated, and distributed a package that informs pilots on the effect that RVSM may have on TCAS. Operators should include this information in the RVSM pilot training program. Training may take the form of a pilot bulletin. This material is published on the FAA web page.

2. Policy Regarding Aircraft System Requirements for RVSM Operations in MMEL (7/18/96) (CG 59). Operators are expected to revise their MEL, as necessary, in accordance with the guidance provided in GC-33. GC-33 is published on the FAA web page.

EXAMPLE OPERATOR APPLICATION

SAMPLE COVER LETTER

Date:

Name of Point of Contact
Principal Operations Inspector
Point of Contact's Office Number
Federal Aviation Administration
Point of Contact's Address

Subject: Application for Approval of XYZ Airline's Reduced Vertical Separation Minimum (RVSM) Program - ABC Aircraft

Reference: FAA "Interim Guidance Material on the Approval of Operators/Aircraft for RVSM Operations (91-RVSM)", dated March 14, 1994

Joint Flight Standards Information Bulletin (FSIB) for Air Transportation (FSAT) and General Aviation (FSGA), Number FSAT 95-22/FSGA 95-12

.

Dear Point of Contact:

Airline XYZ respectfully requests FAA approval to conduct flight operations in Pacific airspace at or above flight level (FL) 290 with 1,000 feet vertical separation (i.e., RVSM operations) using ABC aircraft.

In support of this request, we have prepared the attached approval package. This document has been developed in accordance with the requirements of the referenced guidance material and FSIB/FSAT. In addition, this document will satisfy all requirements for issuance of approved Operations Specifications [FAR Part 121, 125, 135 operators] or Letter of Authorization (LOA) [FAR Part 91 operators] authorizing RVSM operations utilizing ABC aircraft, as outlined in the referenced FSIB/FSAT.

Your review and approval of our attached application for RVSM operations with aircraft ABC is requested. If you have any questions, or require any additional information, please contact (airline's point of contact for RVSM approval) at (telephone number). Airline XYZ expects to start RVSM operations on DD/MM/YY.

Sincerely,

Airline Official
Official's Title

TABLE OF CONTENTS OF APPROVAL PACKAGE

Request for Approval (See cover letter)

APPROVAL FACTORS: BASED ON FAA Interim Guidance Material On The Approval Of Operators/Aircraft For RVSM Operations (91-RVSM)" (March 14, 1994)

	Page Number	91 RVSM Paragraph Reference
AIRWORTHINESS APPROVAL		
Aircraft Manufacturer's Certification	1	9
CONTINUED AIRWORTHINESS - MAINTENANCE REQUIREMENTS		
General	2	10.a
Maintenance Program Approval Requirements	3	10.b
Maintenance Documents Requirements	4	10.c
Maintenance Practices	5	10.d.
Maintenance Practices for Non-compliant Aircraft	7	10.e
Maintenance Training Requirements	8	10.f
Test Equipment	9	10.g
OPERATIONAL APPROVAL		
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Aircraft t ABC Service Bulletin XXXX, dated MM/DD/YY (Appendix I)
Airline XYZ Engineering Authorization (EA) 1-11111-11, dated MM/DD/YY (Appendix II)

Aircraft Manufacturer's Certification

Paragraph 9 of the FAA 91-RVSM Interim Guidance Material specifies the requirements for airworthiness approval of an RVSM data package. These requirements have been complied with by the aircraft manufacturer, and is documented in Aircraft ABC Service Bulletin (SB) XXXX, dated MM/DD/YY.

This SB meets the requirements for the manufacturer's data package, as specified in Paragraph 9 of the FAA "Interim Guidance Material on the Approval of Operators/Aircraft for RVSM Operations (91-RVSM)", dated March 14, 1994, and has been FAA-approved. Consequently, no additional operator-specific approval is required; an operator need only meet the requirements of this SB.

A copy of this SB is included as Appendix I. Airline XYZ has complied with this SB on our ABC aircraft in accordance with Airline XYZ Engineering Authorization (EA) 1-11111-11, dated MM/DD/YY. A copy of this EA is included as Appendix II.

Requirement:

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.

Airline XYZ Response:

Airline XYZ conducts operations as a flag air carrier in accordance with Federal Aviation Regulation (FAR) 121. XYZ maintains its aircraft under an FAA-approved continuous airworthiness maintenance program (CAMP) in accordance with FAR 121 and FAR 43, and in accordance with FAA-approved Operations Specifications, Part D, "Aircraft Maintenance". FAA oversight of Airline XYZ's CAMP and Operations Specifications is provided by the FAA, Flight Standards District Office (FSDO), FSDO Number ##. Accordingly, Airline XYZ's current approved maintenance program is sufficient to maintain the aircraft systems and equipment in accordance with RVSM requirements.

Specific information related to Airline XYZ's maintenance procedures and CAMP for RVSM is contained in subsequent sections in this application.

Airline XYZ operates sufficient maintenance facilities for its ABC aircraft to ensure continued compliance with RVSM requirements. Airline XYZ's primary maintenance base is located at [Airport Name] Airport, in City, State. Additional maintenance support is provided by an extensive network of hangar and line maintenance at various stations throughout the Airline XYZ system.

Requirement:

10. CONTINUED AIRWORTHINESS (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.

Airline XYZ Response:

The following pages list aircraft components required for RVSM, together with scheduled maintenance requirements for that equipment. No RVSM-specific maintenance requirements have been identified by the aircraft manufacturer. A copy of Aircraft ABC Service Bulletin (SB) XXXX, dated MM/DD/YY, which outlines maintenance requirements for RVSM equipment, is included as Appendix III.

- There are no RVSM-specific maintenance requirements for the Aircraft ABC Altimetry/Air-Data system. U.S. airlines who operate under FAR 121 and comply with FAR 43 for periodic maintenance via the Aircraft ABC maintenance planning document (MPD) meet the requirements of FAR 91.411 and 91.401, and therefore need not perform the periodic (2 year) altimeter check for either RVSM or normal operations.

- No RVSM-specific maintenance requirements exist for the automatic altitude control system.

- No scheduled maintenance requirements are outlined for the altitude alert module.

- Periodic checks of the ATC/MODE C Transponder shall be performed per FAR 43, Appendix F, as required by FAR 91.413, at 24 month intervals. Airline XYZ conducts a functional check of the Air Traffic Control System (ATC) at intervals not to exceed 24 months per routine operation 1234.

Note, however, that Aircraft ABC SB XXXX requires replacement of pitot-static probes that have been in service for more than three (3) years. This requirement is detailed on Page 12-1 of this application (reference 91-RVSM - Interim Guidance Material, Paragraph 11.d.(2): "Operational Approval - Content of Operator RVSM Application - Description of Aircraft Equipment").

Requirement:

10. CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS)

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

(1) Maintenance Manuals. (MM)

(2) Structural Repair Manuals. (SRM)

(3) Standards Practices Manuals.

(4) Illustrated Parts Catalogs. (IPC)

(5) Maintenance Schedule.

(6) MMEL/MEL.

Airline XYZ Response:

No RVSM-specific MM procedures have been identified; current MM procedures are sufficient for RVSM equipment.

Airline XYZ will revise the Aircraft ABC SRM to identify the area around the pitot-static probes as RVSM-critical, and to require the Airline XYZ Structures Engineer to be contacted for specific repair instructions in this area. A draft SRM revision is enclosed.

Airline XYZ's Standard Practice Manual will be revised in accordance with the enclosed draft revision. This manual will outline Airline XYZ's standard practices for the necessary RVSM maintenance requirements.

Airline XYZ will revise the aircraft ABC IPC in accordance with Airline XYZ's Engineering Authorization (EA) 22222 (draft copy enclosed) to identify RVSM-critical equipment. This equipment will also be identified as required inspection items (RIIs), requiring work on this equipment to be subject to a "buy-back" inspection per FAR 121.369 and FAR 121.371.

No change to the aircraft ABC maintenance schedule is required for RVSM. Please refer to Page 3-1 for additional information on the required maintenance schedules (reference 91-RVSM - Interim Guidance Material, Paragraph 10.b: "Continued Airworthiness (Maintenance Requirements) - Maintenance Program Approval Requirements").

Please refer to Page 16-1 for a discussion of MMEL/MEL changes for RVSM (reference FAA 91-RVSM Interim Guidance Material, Paragraph 11.d.(6): "Operational Approval - Content of Operator RVSM Application - MEL").

Requirement:

10. CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS)

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 alternations 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.

<u>Airline XYZ Response</u>:

No RVSM-specific maintenance requirements have been identified for aircraft ABC, as detailed in Appendix V. Please refer to Page 3-1 for additional information on required maintenance (reference FAA 91-RVSM Interim Guidance Material, Paragraph 10.b: "Continued Airworthiness (Maintenance Requirements) - Maintenance Program Approval Requirements"). Current Maintenance Manual procedures are acceptable for RVSM, and will continue to be followed.

All RVSM equipment will be identified in the IPC as RVSM-critical, and will be identified as required inspection items, requiring work on this equipment to be subject to a "buy-back" inspection per FAR 121.369 and FAR 121.371. Please refer to Page 4-1 of this application for details on this subject (reference 91-RVSM - Interim Guidance Material, Paragraph 10.c: "Continued Airworthiness (Maintenance Requirements) - Maintenance Documents Requirements").

Requirement:

10. CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS)

e. Maintenance Practices for Non-compliant Aircraft: 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.

Airline XYZ Response:

Airline XYZ will prepare a Standard Practice manual section that outlines responsibilities for RVSM. This manual will detail the requirements for non-compliant aircraft, including notification of Airline XYZ's Maintenance Coordination Center (MCC) and aircraft ABC Fleet Team. The MCC and fleet team will coordinate appropriate action, including:

- adding flight plan remarks to prevent aircraft operation in RVSM airspace until corrective action is accomplished;
- implementing corrective action, and;
- if required, advising Airline XYZ's FAA Liaison section to report the height-keeping performance error to FAA within 72 hours, along with initial analysis of causal factors and measures to prevent further events (refer to Page 23-1 for additional information)

A draft copy of this manual is enclosed with Page 4-1 of this application (reference 91-RVSM Interim Guidance Material, Paragraph 10.c: "Continued Airworthiness (Maintenance Requirements) - Maintenance Documents Requirements").

Requirement:

10. CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS)

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.

Airline XYZ Response:

Airline XYZ's initial maintenance training will be revised to: highlight the importance of the area surrounding the pitot-static probe; emphasize that any defects in the fuselage skin around the probe can affect the accuracy of the altimetry system, and; require inspection of the area around the probe whenever a probe is replaced. Additionally, general RVSM awareness information will be added to the training.

Airline XYZ does not conduct routine recurrent maintenance training. The above information for initial training will also be included in a Maintenance Bulletin for all mechanics who have completed initial training prior to the aforementioned initial training program revision.

Test equipment calibration/usage techniques are currently taught by Avionics coordinators in the Avionics Maintenance area, as "on-the-job training" (OJT). As detailed in this application, no changes to the maintenance programs or inspection schedule are necessary. Accordingly, we believe our current training of test equipment calibration/usage techniques is sufficient, and no changes are warranted.

In addition, since no changes to the maintenance programs or inspection schedule are required, we do not anticipate the need for any special documentation or procedures.

Requirement:

10. CONTINUED AIRWORTHINESS (MAINTENANCE REQUIREMENTS)

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. 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 in-house 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 in-house 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.

Airline XYZ Response:

The maintenance programs identified for RVSM operations can be accomplished without specialized test equipment. Airline XYZ does utilize several test equipment sets to troubleshoot the air data computer system on an “as-needed” basis. These sets are highly accurate, and their calibration procedures can be traced to the national standard.

Additionally, the calibration and accuracy of test equipment used in the Avionics instruments shop are verified in accordance with the requirements outlined in the Component Maintenance Manual and by the equipment manufacturers. The calibration of individual components is performed at periodic intervals, and can be traced to the national standard.

Requirement:

11. OPERATIONAL APPROVAL

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. Flight crew 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)).

Airline XYZ Response:

This application is submitted for approval of RVSM operations with the ABC aircraft only. As detailed on Page 1-1 of this application, and in the Aircraft ABC Service Bulletin contained in Appendix III, the aircraft has been found to meet the airworthiness requirements contained in Paragraph 9 of the FAA Interim Guidance Material.

Additionally, Airline XYZ' various operational programs are scrutinized by the FAA, Flight Standards District Office (FSDO), FSDO number ##. Flight crew and aircraft dispatcher training programs are FAA-approved, as are various operational manuals.

Specific information relating to operational programs, manuals, and training for RVSM can be found in the subsequent sections of this application. Please refer to the Table of Contents in this application for a listing of the discrete elements of this application.

Requirement:

11. OPERATIONAL APPROVAL

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.

Airline XYZ Response:

Airline XYZ has arranged for a pre-application meeting with the FAA/Flight Standards District Office, FSDO Number ##, to be conducted on [date], at [location]. The purpose of this meeting will be to review Airline XYZ's proposed RVSM application for the ABC aircraft.

Requirement:

11. OPERATIONAL APPROVAL

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.

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

Airline XYZ Response:

Specific FAA Airworthiness Approval for RVSM operations with the ABC aircraft has been obtained by the aircraft manufacturer, as documented in Aircraft ABC Service Bulletin (SB) XXXX, dated 1-1-11. A copy of this SB is enclosed as Appendix III. For additional discussion of the Airworthiness Approval for RVSM operations with the ABC aircraft, please refer to Page 1-1 of this application (Aircraft Manufacturer's Certification: Airworthiness Approval).

The FAA-approved Operations Specifications for Airline XYZ, operating certificate XYZA0000, Paragraph A3, authorize Airline XYZ to conduct FAR Part 121 operations using the aircraft listed therein. Airline XYZ's ABC aircraft, the subject of this RVSM application, are listed in that paragraph. A copy of Airline XYZ' Operations Specifications, Paragraph A3, is enclosed.

Paragraph D85 of Airline XYZ' Operations Specifications authorizes Airline XYZ to conduct FAR Part 121 operations using the aircraft individually identified in the attached listing (Airline XYZ' Standard Practice manual, section 00-00-00). Copies of Airline XYZ' Operations Specifications, Paragraph D85, and the pertinent section of Airline XYZ's manual, Section 00-00-00, are enclosed.

Requirement:

11. OPERATIONAL APPROVAL

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.

(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).

Airline XYZ Response:

The following pages list aircraft components required for RVSM, together with scheduled maintenance requirements for that equipment.

This equipment will be identified in the IPC as RVSM-critical components. Additionally, this equipment will be identified as "Required Inspection Items" (RIIs), and will be subject to "buy-back" inspection procedures outlined in FAR 121.369 and FAR 121.371. Please refer to Page 4-1 for additional information on the IPC and RIIs (reference FAA 91-RVSM Interim Guidance Material, Paragraph 10.c: "Continued Airworthiness (Maintenance Requirements) - Maintenance Documents Requirements").

Aircraft ABC SB XXXX requires replacement of pitot-static probes that have been in service for more than three (3) years. Airline XYZ's aircraft ABC Fleet Team will monitor this requirement, and ensure that pitot-static tubes that have been in service for three or more years are replaced before the aircraft is operated in RVSM operations. However, we anticipate that certification activities currently underway by Pitotstatic Company (the manufacturer of the probes) will result in a plated probe that will have unlimited service life, and will not require replacement after three years of service. We plan to install these probes on our ABC aircraft when the probes are available.

<u>Requirement</u>:

11. <u>OPERATIONAL APPROVAL</u>

d. <u>Content of Operator RVSM Application</u>: 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.

(3) <u>Operations Training Programs and Operating Practices and Procedures</u>: FAR Part 121 and FAR Part 135 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). FAR Part 91 operators should demonstrate to the FAA through oral or written tests that their knowledge of RVSM operating practices and procedures is equivalent to FAR Part 121 and FAR Part 135 operators and is sufficient to warrant granting of approval to conduct RVSM operations. 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, in-flight procedures, and flight crew training procedures. Appendix X presents procedures that are unique to Pacific airspace.

CHANGE. PILOT TRAINING RELATED TO TCAS OPERATION IN RVSM. Part 121, 125, and 135 125 operators must include pilot training on TCAS operation in RVSM in their application for RVSM authority/approval. Part 91 operators/aircraft equipped with TCAS operator are encouraged to provide information to their pilots.

<u>Airline XYZ Response</u>:

<u>Initial training</u>: RVSM will be introduced to Airline XYZ aircraft dispatchers and flight crewmembers during the 1996 recurrent training classes, commencing in January, 1996, using the enclosed training syllabi. These same syllabi will be added to, and become a standard part of, the initial flight training for flight crewmembers, and the international initial class curriculum for new aircraft dispatchers.

<u>Recurrent Training</u>: In 1996 and subsequent international recurrent classes, a review of RVSM operations and any new or changed procedures will become a standard part of the curriculum.

Our operating practices and procedures will be standardized in accordance with the enclosed syllabi.

Requirement:

11. OPERATIONAL APPROVAL

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.

(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. Appropriate manuals should include a statement of the airspeeds, altitudes, and weights considered in RVSM aircraft approval to include identification of any operating restrictions established for that aircraft group. (See paragraph 7c(4)(iii)). Manuals and checklists should be submitted for authority review as part of the application process.

Airline XYZ Response:

Four (4) manuals will need to be updated with information about RVSM: the Flight Department Manual (FDM), the Dispatcher's Training Manual (DTM), the Airline XYZ Airway Manual (AM), and the Aircraft ABC Pilot's Manual (PM).

Flight Department Manual: The long-range operations section will be revised to include background and general guidance information for RVSM operations. Additionally, there exists a separate section within the FDM for aircraft dispatchers, called the dispatcher's supplement (DS). In this section, a brief description of RVSM will be inserted, following the general outlines of the aircraft dispatcher's RVSM training syllabus.

Dispatcher's Training Manual: In this new manual, the description of the international initial and recurrent classes will include references to RVSM training, down to the level of detail on aircraft dispatcher's RVSM training syllabus, if appropriate.

Airline XYZ Airway Manual: The route information section will be revised to include specific RVSM operational procedures applicable to NAT/MNPS.

Aircraft ABC Pilot's Manual: The abnormal procedures section will be revised to include appropriate contingency procedures outlined on the flight crewmembers initial training syllabus.

Note: Copies of the aircraft dispatchers and flight crewmember RVSM training syllabi referred to on this page can be found enclosed with Page 13-1 of this application (reference FAA 91-RVSM Interim Guidance Material, Paragraph 11.d.(3): "Operational Approval - Content of Operator RVSM Application - Operations Training Programs and Operating Practices and Procedures").

Requirement:

11. OPERATIONAL APPROVAL

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.

(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.

Airline XYZ Response:

The flight crew operating report system was reviewed for the previous 12 months. No incidents of height-keeping performance errors were noted for the aircraft ABC fleet.

A review of the Equipment Removal History will be conducted for the previous 12 months, to determine if any failures have been detected on RVSM equipment. This review will examine the RVSM equipment identified on Page 12-1 of this application (reference FAA 91-RVSM Interim Guidance Material, Paragraph 11.d.(2): "Operational Approval - Content of Operator RVSM Application - Aircraft Equipment").

Requirement:

11. OPERATIONAL APPROVAL

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.

(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.

CHANGE. Operators are expected to revise their MEL's in accordance with the guidance published in GLOBAL CHANGE (GC)-33. GC-33 is published on the ARINC bulletin board.

Airline XYZ Response:

The aircraft manufacturer has stated that no MMEL revisions specific to RVSM are planned.

The current Airline XYZ aircraft ABC Minimum Equipment List (MEL) requires the primary altimeter, flight control computer, TCAS, and altitude hold systems to be operational. The Airline XYZ aircraft ABC MEL will be revised to require the Altitude Alert System (AAS) to be operative for flights in RVSM airspace.

Requirement:

11. OPERATIONAL APPROVAL

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.

(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.

Airline XYZ Response:

No RVSM-specific maintenance program changes will be required. Please refer to Page 3-1 of this application for details (reference FAA 91-RVSM Interim Guidance Material, Paragraph 10.c: "Continued Airworthiness (Maintenance Requirements) - Maintenance Program Approval Requirements").

Pitot-static tubes must be replaced after three years in service. Please refer to Page 12-1 of this application for details (reference FAA 91-RVSM Interim Guidance Material, Paragraph 11.d.(2): "Operational Approval - Content of Operator RVSM Application - Aircraft Equipment").

Requirement:

11. OPERATIONAL APPROVAL

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.

(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. (See paragraph 11h for further discussion of verification/monitoring programs).

Airline XYZ Response:

Background

In order to help assess the continuing operational and mathematical integrity of the airspace system in an RVSM environment, operators are required to participate in both a pre-operational verification of aircraft height keeping performance and a post-operational monitoring of same. To perform the verification/monitoring of aircraft altitude-keeping performance, the Asia-Pacific Registry and Monitoring Organization (APARMO) is planning to use the Global Positioning System (GPS)-based Monitoring System (GMS). The GMS is administered by the APARMO. The APARMO processes the data to estimate altimetry system error (ASE) and total vertical error (TVE). An operator without RVSM experience should plan to have three of each of its aircraft types monitored within three months of approval. Operators with RVSM experience should have two aircraft of each type monitored. The APARMO will notify the operator when the monitoring data is sufficient.

RVSM Aircraft Monitoring

The monitoring of an approved RVSM fleet will be carried out through the GPS-based Monitoring System (GMS). Therefore, Airline XYZ proposes the following plan for each fleet of aircraft which it intends to operate in RVSM airspace.

- ➔ A member of the aircraft ABC Fleet Team from Airline XYZ will contact the APARMO support contractor when aircraft have been inspected and modified as per the manufacturer's RVSM Service Bulletin.

- ➔ Airline XYZ will arrange with the GMS support contractor to operate a GPS-based monitoring Unit (GMU) on one leg of a revenue flight, most likely a domestic one. While initial flights may require GMS support contractor participation in the installation and removal of the GMU, it is intended that the majority of verification flights will have the GMU installed and removed by licensed Airline XYZ line maintenance personnel.

- ➔ When the verification flight has terminated, the GMU and collected data will be returned to GMS support contractor for post-processing.

- ➔ ASE and TVE for the flight will be derived by the APARMO. ASE and TVE may be obtained by sending a fax request to the APARMO at (+1 609 485 5117). A successful flight will also be annotated on the APARMO website: www.tc.faa.gov/act500/rvms/aparmo-intro.html. The APARMO will contact the operator when a flight is unsuccessful and arrange for a repeat measurement.

➔ RVSM Aircraft Monitoring Following Trials Period

The requirements for aircraft altitude-keeping performance monitoring after implementation have not yet been established. The APANPIRG RVSM Task Force will establish those requirements

.

11. OPERATIONAL APPROVAL

e. Authority 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.

Airline XYZ Response:

Airline XYZ requests review, evaluation, and approval of this application for aircraft ABC RVSM operations.

Airline XYZ believes the content of this application is sufficient. However, if additional information is requested from FAA, Airline XYZ will provide it in a timely manner.

Airline XYZ RVSM Points of Contact are:

Airline XYZ RVSM Coordinators

NAME	TITLE	Phone Number
NAME	TITLE	Phone Number

Requirement:

11. OPERATIONAL APPROVAL

f. Validation Flight(s): 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.

Airline XYZ Response:

Airline XYZ does not believe a validation flight should be required, for the following reasons:

- As noted previously, aircraft ABC RVSM operations will not require any maintenance program changes or use of any new, specialized maintenance procedures;
- Airline XYZ operates in accordance with an FAA-approved continuous airworthiness maintenance program (CAMP) in accordance with FAR 121 and FAR 43, and in accordance with FAA-approved Operations Specifications, Part D, "Aircraft Maintenance";
- Airline XYZ has operated and maintained ABC aircraft since [date];
- Airline XYZ's crew training and operational programs are FAA-approved, and;
- A review of the Airline XYZ flight crew operating report system for the previous 12 months revealed no height-keeping performance errors.

Accordingly, we do not believe a validation flight is necessary.

If FAA requires a validation flight, we propose to accomplish such a flight in conjunction with a scheduled Airline XYZ revenue operation (i.e., a revenue validation flight).

Requirement:

11. OPERATIONAL APPROVAL

g. Form of Authorizing Document

(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). Each aircraft type group for which the operator is granted authority should be listed in Operational Specifications.

(2) FAR Part 91 Operators: 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.

Airline XYZ Response:

The above requirement states, "Approval to operate in RVSM should be granted through the issuance of an operations specifications paragraph from Part B ..." However, FSIB/FSAT 95-22 stipulates, "Interim approval can be granted through a letter to the operator stating that RVSM approval has been given, and that OPSPECS will be issued only after the FAR pertaining to RVSM is published."

Airline XYZ requests appropriate authorizing documents be issued to authorize aircraft ABC RVSM operations, based upon the data contained in this application.

Note that requirements 11.g.(1) and 11.g.(2), above, are mutually exclusive, and the latter does not apply to Airline XYZ.

Requirement:

11. OPERATIONAL APPROVAL

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.

Airline XYZ Response:

Please refer to Page 18-1 of this application for details on Airline XYZ' Verification/Monitoring Programs for RVSM (reference FAA 91-RVSM Interim Guidance Material, Paragraph 11.d.(8): "Operational Approval - Content of Operator RVSM Application - Plan for Participation in Verification/Monitoring Programs").

Requirement:

11. OPERATIONAL APPROVAL

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.

Airline XYZ Response:

An Airline XYZ Standard Practice manual section will outline the responsibilities for monitoring Airline XYZ's RVSM program. A draft copy of this manual is enclosed with Page 4-1 of this application (reference FAA 91-RVSM Interim Guidance Material, Paragraph 10.c: "Continued Airworthiness (Maintenance Requirements) - Maintenance Documents Requirements").

A revision to the Airline XYZ Airway Manual will describe flight crewmember reporting functions for any suspected RVSM height-keeping performance errors. The Aircraft ABC program manager will be responsible for monitoring the flight crew operating report system, and notifying appropriate departments (Aircraft ABC Fleet Team, Maintenance Coordination Center (MCC), etc.) of any height-keeping errors. The MCC and fleet team will coordinate appropriate action, including:

- adding flight plan remarks to prevent aircraft operation in RVSM airspace until corrective action is accomplished;
- implementing corrective action, and ;
- advising Airline XYZ's FAA Liaison section to report the height-keeping performance error to FAA within 72 hours, along with initial analysis of causal factors and measures to prevent further events.

APPENDIX I

Aircraft ABC Service Bulletin XXXX, dated 1-1-11

"Initial Qualification of Aircraft ABC Airplanes for
Reduced Vertical Separation Minimum (RVSM) Operation"

APPENDIX II

Airline XYZ's Engineering Authorization (EA) 1-11111-11,
dated MM/DD/YY

"Structural Inspection to Allow
Reduced Vertical Separation Minimum (RVSM) Operation"

Apéndice G

Fraseología para las Operaciones RVSM

Fraseología Controlador-Piloto:

Mensaje	Fraseología
Para que un controlador averigüe el estado de aprobación RVSM de una aeronave …	(distintivo de llamada) **CONFIRME RVSM APROBADA**
Para que un Piloto informe que no tiene aprobación RVSM: i. en la llamada inicial en cualquier frecuencia dentro del espacio aéreo RVSM (los controladores colacionarán con la misma frase); ii. en todas las solicitudes de cambios de nivel de vuelo de los niveles de vuelo dentro del espacio aéreo RVSM; y iii. en todas las colaciones de autorizaciones sobre niveles de vuelo de los niveles de vuelo dentro del espacio aéreo EUR RVSM **Además, excepto en el caso de aeronaves de Estado, los Pilotos incluirán esta frase RTF para colacionar autorizaciones de niveles de vuelo que impliquen el tránsito vertical a través de FL 290 o FL 410.** *Ver siguientes ejemplos.*	**RVSM NEGATIVA***
Para que un Piloto informe que tiene aprobación RVSM	**RVSM AFIRMA***
Para que el Piloto de una aeronave de Estado sin aprobación RVSM notifique que no posee aprobación RVSM en respuesta a la frase indicada en **CONFIRME RVSM APPOBADA.**	**AERONAVE DE ESTADO RVSM NEGATIVA ***
Para que el control de tránsito aéreo niegue una autorización para entrar en el espacio aéreo RVSM:	(distintivo de llamada) **IMPOSIBLE APROBAR ENTRADA EN ESPACIO AÉREO RVSM, MANTENGA [o DESCIENDA A, o ASCIENDA A] NIVEL DE VUELO (**número**)**
Para que un Piloto o notifique cuando una turbulencia fuerte afecte la capacidad de la aeronave para mantener los requisitos de mantenimiento de altura para la RVSM.	**INCAPACIDAD RVSM DEBIDO A TURBULENCIA ***

Mensaje	Fraseología
Para que un Piloto notifique que el equipo de aeronave se ha degradado por debajo de los MASPS requeridos para el vuelo dentro del espacio aéreo RVSM. *(Esta frase debe usarse para comunicar, inicialmente, la imposibilidad de cumplir los MASPS y después, en el contacto inicial en todas las frecuencias dentro de los límites laterales del espacio aéreo RVSM, hasta el momento en que el problema deje de existir o la aeronave haya abandonado el espacio aéreo RVSM).*	**INCAPACIDAD RVSM DEBIDO A EQUIPO** *
Para que un Piloto notifique la capacidad de reanudar la operación dentro del espacio aéreo EUR RVSM después de una contingencia de equipo o relacionada con el tiempo.	**LISTO PARA REANUDAR RVSM***
Para que un controlador confirme que una aeronave ha recuperado su aprobación RVSM o para confirmar que el Piloto está listo para reanudar las operaciones RVSM.	**NOTIFIQUE LISTO PARA REANUDAR RVSM**

Ejemplo 1: Una aeronave no aprobada RVSM que mantiene FL 260, subsecuentemente solicita ascenso a FL 320.

Piloto : (distintivo de llamada) SOLICITA FL 320, RVSM NEGATIVA
Controlador: (distintivo de llamada) ASCENDER A FL 320
Piloto : (distintivo de llamada) ASCENDER A FL 320, RVSM NEGATIVA

Ejemplo 2: Una aeronave no aprobada RVSM, manteniendo FL 260, subsecuentemente solicita un ascenso a FL 430.

Piloto : (distintivo de llamada) SOLICITA FL 430, RVSM NEGATIVA
Controlador: (distintivo de llamada) ASCIENDE A FL 430
Piloto : (distintivo de llamada) ASCIENDE A FL 430, RVSM NEGATIVA

Ejemplo 3: Una aeronave no aprobada RVSM, que mantiene FL 360, subsecuentemente solicita ascenso a FL 380.

Piloto : (distintivo de llamada) SOLICITA FL 380, RVSM NEGATIVA
Controlador: (distintivo de llamada) ASCIENDE A FL 380
Piloto : (distintivo de llamada) ASCIENDE A FL 380, RVSM NEGATIVA

Ejemplo 4: Una aeronave no aprobada RVSM, que mantiene FL 280, subsecuentemente solicita ascenso a FL 320.

Piloto : (distintivo de llamada) SOLICITA FL 320, RVSM NEGATIVA
Controlador: (distintivo de llamada) IMPOSIBLE AUTORIZACIÓN EN ESPACIO AEREO RVSM, MANTENGA FL 280

Coordinación entre dependencias ATS:

Para	Mensaje	Fraseología
1	Verbalmente suplir un mensaje automatizado estimado que no transfiere automáticamente información de la casilla 18 del plan de Vuelo.	**RVSM NEGATIVA** o **AERONAVE DE ESTADO RVSM NEGATIVA** [Si es aplicable]
2	Verbalmente suplir mensajes estimados de aeronave no aprobada RVSM.	**RVSM NEGATIVA** o **AERONAVE DE ESTADO RVSM NEGATIVA** [Si es aplicable]
3	Comunicar la causa de una contingencia relacionada a una aeronave que no puede realizar Operaciones RVSM debido a turbulencia severa u otros fenómenos severos relacionados con el clima (o falla del equipo, si es aplicable).	**INCAPACIDAD RVSM DEBIDO A TURBULENCIA** **[**o **EQUIPO** si es aplicable**]**

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