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AVIACIÓN CIVIL
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(2014)

Comisión de Meteorología Aeronáutica
Decimoquinta reunión

Montreal, 7 - 18 de julio de 2014

INFORME SOBRE LA CUESTIÓN 2 DEL ORDEN DEL DÍA

(Todas las cuestiones del orden del día fueron consideradas de manera conjunta con la Decimoquinta Reunión de la Comisión de Meteorología Aeronáutica de la Organización Meteorológica Mundial)

El presente informe será examinado por la Comisión de Aeronavegación y el Consejo de la OACI, así como por el Consejo Ejecutivo de la OMM. Las decisiones de estos órganos relativas a las recomendaciones de la reunión figurarán en un suplemento al informe de la reunión, que se publicará oportunamente.

Cuestión 2 del orden del día: Mejoramiento de la seguridad operacional y la eficiencia de la navegación aérea internacional mediante el suministro de servicio meteorológico perfeccionado

2.1: Mejoramiento del suministro de servicio meteorológico existente en apoyo de la actual toma de decisiones operacionales pre-tácticas y tácticas estratégicas (comprendido el Módulo B0-AMET de las ASBU)

2.1.1 La reunión consideró propuestas relacionadas con el mejoramiento del sistema mundial de pronósticos de área (WAFS) existente, los aspectos del servicio fijo aeronáutico (AFS) y el progreso alcanzado en otras áreas desde la celebración en 2002 de la última Reunión Departamental de Meteorología (MET/02). Asimismo, la reunión tomó nota de nueve notas de información relacionadas con esta cuestión 2.1 del orden del día.

Servicio de meteorología aeronáutica en los aeródromos y en el área terminal, incluyendo la información OPMET

2.1.2 La reunión se mostró complacida al tomar nota del importante progreso logrado desde la celebración de la Reunión MET/02, en particular en lo que respecta a la automatización de los sistemas de observación en los aeródromos y a la introducción de pronósticos de aeródromo de hasta 30 horas en determinados aeródromos.

El sistema mundial de pronósticos de área (WAFS), el sistema de distribución por satélite del servicio fijo aeronáutico y los servicios basados en la Internet

2.1.3 La reunión tomó nota con satisfacción de que, desde que se celebró la MET/02, se han realizado mejoras significativas en el programa del WAFS, entre ellas la mayor resolución espacial y temporal de los pronósticos mundiales reticulares en altitud del WAFS (incluyendo una transición de cada seis horas a cada tres, de una cuadrícula horizontal reducida de 1,25° a una cuadrícula horizontal regular (no reducida) de 1,25° y una mayor resolución vertical, particularmente en altitudes de crucero) y la elaboración y aplicación operacional de pronósticos mundiales reticulares WAFS para engelamiento, turbulencia y nubes cumulonimbus.

2.1.4 La reunión convino en que los cambios del WAFS de 2013 a 2018 deberían centrarse en mejoras de los pronósticos mundiales reticulares del WAFS para engelamiento y turbulencia. Al respecto, la reunión examinó y acordó los principios que se aplicarán (bajo la forma de resultados esperados) como base para el desarrollo futuro del WAFS a fin de apoyar el módulo B0-AMET de la metodología de las mejoras por bloques del sistema de aviación (ASBU). Por lo tanto, la reunión formuló la recomendación siguiente:

Recomendación 2/1 — Desarrollo del WAFS en apoyo de la metodología ASBU hasta 2018

Que la OACI, a través de un grupo de expertos apropiado, utilice los principios esbozados en los resultados esperados que se incluyen en el Apéndice A como base para el desarrollo futuro del sistema mundial de pronósticos de área (WAFS) en apoyo del módulo B0-AMET de la metodología de mejoras por bloques del sistema de aviación (ASBU), que figura en el *Plan mundial de navegación aérea* (GANP) (Doc 9750).

2.1.5 Con relación al sistema de distribución por satélite de información relativa a la navegación aérea (SADIS) del AFS utilizado para difundir o proporcionar a los Estados y usuarios autorizados información OPMET mundial y pronósticos WAFS, la reunión tomó nota de los avances importantes logrados desde la celebración de la Reunión MET/02, los cuales condujeron a la radiodifusión por satélite de segunda generación SADIS (SADIS 2G) y/o al servicio FTP basado en la Internet segura del SADIS que actualmente están utilizando operacionalmente más de 180 usuarios autorizados en casi 110 Estados en las Regiones Europa (EUR), Oriente Medio (MID) y África-Océano Índico (AFI) de la OACI, así como en la parte occidental de la Región Asia/Pacífico (APAC). La reunión convino en que, tratándose completamente de un servicio cuyos costos se recuperan, era necesario asegurarse de que el SADIS siga operando de acuerdo con las expectativas de los usuarios y desarrollándose de manera acorde con la evolución del GANP y la metodología ASBU ahí contenida. Asimismo, la reunión estuvo de acuerdo en que dicho desarrollo, como el del servicio de ficheros Internet del WAFS (WIFS) que presta servicio a las Américas y la parte oriental de la Región Asia-Pacífico, debería armonizarse con el futuro entorno de gestión de la información de todo el sistema (SWIM) y el trabajo de otros grupos de expertos de la OACI responsables del desarrollo del SWIM. Por lo tanto, la reunión formuló la recomendación siguiente:

Recomendación 2/2 — Operación y desarrollo futuro del sistema de distribución por satélite del servicio fijo aeronáutico y de los servicios basados en la Internet

Que, con carácter de urgente, se encargue a un grupo de expertos apropiado de la OACI que se asegure de que la operación del sistema de distribución por satélite de información relativa a la navegación aérea (SADIS) del servicio fijo aeronáutico (AFS), y de los servicios basados en la Internet FTP seguro de SADIS y de ficheros Internet del WAFS (WIFS), siga respondiendo a las expectativas de los usuarios y desarrollándose de manera acorde con el *Plan mundial de navegación aérea* (Doc 9750), lo que incluye:

- a) la consideración de la función del SADIS y del WIFS en el futuro entorno de gestión de la información de todo el sistema (SWIM) que es la base de un sistema de gestión del tránsito aéreo interoperable a nivel mundial; y
- b) la armonización de las actividades futuras que lleve a cabo la OACI en el campo de la gestión de la información.

2.1.6 Respecto al futuro de la radiodifusión por satélite SADIS 2G más allá de 2015, la reunión estuvo de acuerdo con una opinión técnica que expresó el Grupo sobre operaciones SADIS (SADISOPSG) de que la SADIS 2G debería extenderse más allá de 2015, pero únicamente hasta noviembre de 2019, y concluyó que, entre tanto, no sería viable invertir en una mejora del sistema. Por consiguiente, la reunión formuló la recomendación siguiente:

Recomendación 2/3 — Retiro de la radiodifusión por satélite del SADIS 2G y pruebas formales del intercambio de información OPMET mundial y pronósticos WAFS por el AMHS

Que la OACI, a través de un grupo de expertos apropiado, se encargue de:

- a) tomar las medidas necesarias para garantizar que la radiodifusión por satélite del SADIS 2G se prolongue más allá de 2015, pero no después de noviembre de 2019;
- b) instar a los Estados/usuarios interesados que todavía no lo hayan hecho, a que empiecen a usar el servicio FTP seguro del SADIS en el período intermedio descrito en a); y
- c) realizar, con carácter urgente, pruebas formales del intercambio de información OPMET mundial y de pronósticos del sistema mundial de pronósticos de área (WAFS) por el sistema de tratamiento de mensajes de ATS (AMHS), a fin de determinar la capacidad y las especificaciones mínimas requeridas para distribuir en el futuro tales datos a los Estados/usuarios.

La vigilancia de los volcanes en las aerovías internacionales (IAVW) y otros aspectos relativos a la liberación de material radiactivo en la atmósfera y a la meteorología del espacio

2.1.7 La reunión tomó nota de las mejoras importantes desde la MET/02 en la vigilancia de los volcanes en las aerovías internacionales (IAVW) que incluían la observación en tiempo real o casi real, la detección y notificación de erupciones volcánicas y cenizas volcánicas en la atmósfera, y en los pronósticos del transporte y la dispersión de las cenizas volcánicas. La reunión observó además que algunos de estos avances fueron motivados, en particular, por las grandes erupciones volcánicas como las de Eyjafjallajökull y Grimsvötn en Islandia en 2010 y 2011 respectivamente, y Puyehue-Cordón Caulle en Chile en 2011. La reunión tomó nota de que la OACI, en estrecha colaboración con la OMM, había establecido un Grupo especial internacional sobre cenizas volcánicas (IVATF) que complementó el trabajo del Grupo de operaciones para vigilancia de volcanes en las aerovías internacionales (IAVWOPSG) entre 2010 y 2012, para ayudar a avanzar en una serie de consideraciones científicas, técnicas y operacionales que habían salido a la luz a raíz de las erupciones. Además, la reunión tomó nota con beneplácito de que el Grupo científico asesor en cenizas volcánicas (VASAG) de la Organización Meteorológica Mundial (OMM)/Unión Internacional de Geodesia y Geofísica (IUGG), se había establecido en marzo de 2010 inmediatamente antes de la erupción de Eyjafjallajökull, y de que el VASAG había sido fundamental para proporcionar información científica al IVATF y al IAVWOPSG.

2.1.8 La reunión tomó nota de que el IAVWOPSG había empezado a preparar una hoja de ruta para la IAVW, así como conceptos de operación referentes a la información sobre la liberación de material radiactivo en la atmósfera y a las condiciones meteorológicas espaciales, todo esto con el propósito de ayudar a entender la forma en que debía evolucionar la prestación de servicio en los próximos años en apoyo del sistema emergente de la gestión del tránsito aéreo mundial.

Información sobre condiciones meteorológicas peligrosas, incluyendo peligros en ruta

2.1.9 La reunión tomó nota de que la tarea principal del Grupo de estudio sobre alertas meteorológicas (METWSG), establecido por la OACI en 2007, había sido revisar las disposiciones del Anexo 3/Reglamento Técnico [C.3.1] relativas al contenido y la expedición de información SIGMET, para satisfacer las necesidades cambiantes de las operaciones de vuelo y para resolver los problemas de implementación del SIGMET que han tenido desde hace tiempo muchos Estados. A este respecto, la reunión tomó nota con beneplácito de que el METWSG había realizado, en 2011, una prueba del suministro de información de asesoramiento SIGMET en la Región AFI y parte de la Región APAC, con la contribución significativa de China, Francia y Sudáfrica que habían servido de centros de avisos SIGMET durante la prueba. Atendiendo a los resultados positivos de la prueba, la reunión tomó nota de una propuesta para el establecimiento de un sistema de avisos sobre condiciones meteorológicas peligrosas a escala regional (se aborda en el marco de la cuestión 2.2 del orden del día).

2.1.10 La reunión tomó nota, asimismo, de otros acontecimientos relacionados que surgieron del METWSG, incluyendo una propuesta de enmienda del Anexo 3/Reglamento Técnico [C.3.1] para mejorar, en particular, la preparación de información SIGMET y AIRMET relativa a condiciones meteorológicas peligrosas, incluyendo peligros en ruta (se aborda en el marco de la cuestión 5.1 del orden del día).

Cuestión 2 del orden del día: Mejoramiento de la seguridad operacional y la eficiencia de la navegación aérea internacional mediante el suministro de servicio meteorológico perfeccionado

2.2: Mejoramiento de la información meteorológica integrada en apoyo de la toma de decisiones operacionales pre-tácticas y tácticas estratégicas a partir de 2018 (comprendido el Módulo B1-AMET de las ASBU)

2.2.1 Respecto al mejoramiento del servicio meteorológico aeronáutico a partir de 2018, la reunión consideró propuestas relativas al mejoramiento del sistema mundial de pronósticos de área (WAFS) y de la vigilancia de los volcanes en las aerovías internacionales (IAVW) y al suministro de información sobre las condiciones meteorológicas espaciales, la liberación de material radiactivo y sustancias químicas tóxicas y otros fenómenos meteorológicos peligrosos. Asimismo, la reunión tomó nota de 14 notas de información sobre la cuestión 2.2 del orden del día.

Consideraciones generales sobre el establecimiento de futuros requisitos de información meteorológica aeronáutica

2.2.2 La reunión apoyó, en principio, la evolución del WAFS y de la IAVW actuales y la elaboración ulterior de disposiciones en materia de información sobre las condiciones meteorológicas espaciales, la liberación de material radiactivo y sustancias químicas tóxicas y otros fenómenos meteorológicos peligrosos. Sin embargo, la reunión fue de la opinión de que debería estudiarse más la evolución general de la prestación de servicios meteorológicos aeronáuticos en el contexto del cambiante entorno del transporte aéreo y en la elaboración de un marco de disposiciones para los servicios locales, subregionales, regionales, multirregionales y mundiales. En el contexto de dicho marco, la reunión tomó nota de que las disposiciones podrían apoyar el concepto según el cual se tendrían comunidades usuarias a diferentes niveles –p. ej., usuarios aeroespaciales individuales, operaciones de líneas aéreas y diferentes servicios o funciones de tránsito aéreo– y, al mismo tiempo, garantizar el intercambio de información MET basándose en la eficiencia y de manera rentable, proporcional y ágil en cuanto al uso operacional de la misma y para satisfacer los objetivos del Bloque 1 de la metodología de las mejoras por bloques del sistema de aviación (ASBU) contenida en el *Plan mundial de navegación aérea* (GANP) (Doc 9750) y otros objetivos conexos. La reunión convino en que era imprescindible evaluar la futura gestión y gobernanza del sistema meteorológico aeronáutico que presta servicios para la navegación aérea internacional, identificándose claramente los cambios que se requieren. Además, se tomó nota de que si bien el desarrollo de tecnología era parte integral de los futuros servicios previstos, seguiría siendo importante que la prestación de servicios no deje de ser colaborativa e incluyente. En consecuencia, la reunión formuló la recomendación siguiente:

Recomendación 2/4 — Examen del marco de suministro del servicio de información meteorológica para reflejar los objetivos del GANP

Que se inste a la OACI a que, a través de un grupo de expertos apropiado, en estrecha coordinación con la OMM y para apoyar los objetivos generales de seguridad operacional y eficiencia:

- a) examine el marco de “suministro del servicio de información MET” existente establecido en el Anexo 3 — *Servicio meteorológico para la navegación aérea internacional*, teniendo en cuenta las necesidades emergentes de los usuarios –incluidos los servicios de tránsito aéreo/gestión del

tránsito aéreo– de contar con información meteorológica constante, coherente, precisa, acreditada y adecuada a los fines, de acuerdo con los requisitos de eficiencia para apoyar los objetivos generales del *Plan mundial de navegación aérea* (GANP) (Doc 9750);

- b) se asegure de que las prioridades iniciales del examen, que debería finalizarse para 2016, se definan, en un esfuerzo consolidado, conjuntamente con:
 - i) el futuro desarrollo del sistema mundial de pronósticos de área (WAFS), la vigilancia de los volcanes en las aerovías internacionales (IAVW), así como la elaboración de disposiciones relativas a la información meteorológica espacial y la liberación a la atmósfera de materiales radiactivos;
 - ii) el desarrollo e implantación de un sistema regional de avisos para determinadas condiciones meteorológicas peligrosas en ruta para los Estados en los que existen deficiencias relacionadas con la información SIGMET;
 - iii) el apoyo MET para las operaciones basadas en las trayectorias en general y a la toma de decisiones en colaboración, incluso a nivel de aeropuerto y de red; y
 - iv) la elaboración de orientación para los Estados respecto a la forma en que pueden cumplir sus obligaciones para con la OACI en el contexto de los servicios meteorológicos locales, subregionales, regionales, multirregionales y mundiales, incluidas consideraciones sobre recuperación de costos y gobernanza;
- c) se asegure de que los resultados del examen mencionado se consideren al actualizar el GANP y los módulos pertinentes de las mejoras por bloques del sistema de aviación (ASBU); y
- d) se asegure de que se definan principios rectores que respeten los mandatos de la OACI y la OMM para que los Estados faciliten una prestación de servicios MET incluyente a niveles local, subregional, regional, multirregional y mundial, cuando se requiera, y que las comunidades usuarias locales, subregionales, regionales, multirregionales y mundiales puedan utilizar esta información en sus operaciones.

2.2.3 Además de lo que precede, la reunión consideró las necesidades de los pilotos, específicamente en el contexto de las necesidades de los usuarios durante la transición al suministro en forma digital de información meteorológica aeronáutica, de acuerdo con lo previsto en el GANP. Al respecto, la reunión tomó nota de varias cuestiones, en particular las relativas a la visualización de dicha información, que se consideraría más tarde en el contexto de la automatización y los factores humanos (consideraciones que se tratan bajo la cuestión 2.4 del orden del día).

Sistema mundial de pronósticos de área (WAFS)

2.2.4 La reunión tomó nota del trabajo que se había realizado con respecto a la preparación de una hoja de ruta para facilitar los requisitos futuros del WAFS. En concordancia con la evolución futura del GANP, la reunión tomó nota de que se preveía que la hoja de ruta evolucionaría en los años venideros para garantizar que los niveles de servicio satisfagan las necesidades actuales y futuras. En consecuencia, la reunión convino en que era vital, como parte del enfoque holístico del suministro de servicio futuro, que el WAFS siguiera evolucionando en consonancia con el GANP de manera eficaz en función de los costos mediante una gobernanza apropiada. Además, la reunión convino en que la información producida en el marco del WAFS debía integrarse en el futuro entorno de gestión de la información de todo el sistema (SWIM), comprendidos los formatos de datos interoperables que han de utilizarse, basándose en el modelo de intercambio de información meteorológica (WXXM) de la OACI.

2.2.5 La reunión convino en que las modificaciones del WAFS en el plazo de 2018 a 2023 del Bloque 1, además de aquellas en el plazo de 2023 a 2028 del Bloque 2, debían centrarse en los principios que figuran en el Apéndice B. Al respecto, la reunión examinó los principios y convino en que se utilicen como base de la evolución futura del WAFS. En consecuencia, la reunión formuló la recomendación siguiente:

Recomendación 2/5 — Evolución futura del WAFS

Que un grupo de expertos apropiado de la OACI, en estrecha coordinación con la OMM:

- a) elabore los requisitos futuros del sistema mundial de pronósticos de área (WAFS) en concordancia con el *Plan mundial de navegación aérea* (Doc 9750), comprendida la integración de la información producida por el WAFS en el futuro entorno de gestión de la información de todo el sistema (SWIM) en apoyo del sistema de gestión del tránsito aéreo interoperable a escala mundial; y
- b) utilice los principios descritos en los resultados esperados que figuran en el Apéndice B como base de la evolución futura del WAFS en los plazos de los Bloques 1 y 2 de la metodología de las mejoras por bloques del sistema de aviación (ASBU).

Vigilancia de los volcanes en las aerovías internacionales (IAVW)

2.2.6 La reunión tomó nota de las importantes mejoras de la IAVW desde la celebración de la Reunión Departamental de Meteorología (2002) (MET/02), así como de la elaboración de una hoja de ruta para facilitar los futuros requisitos para la IAVW. La reunión tomó nota de que, de acuerdo con la evolución futura del GANP, se esperaba que la hoja de ruta para la IAVW evolucionaría en los años

venideros para garantizar que los niveles de servicio satisfagan las necesidades actuales y futuras. En consecuencia, la reunión convino en que era vital que la IAVW siguiera evolucionando en consonancia con el GANP y que la información producida en el marco de la IAVW debería integrarse en el futuro entorno SWIM. La reunión convino en que debería utilizarse la hoja de ruta que figura en el Apéndice C como base para la definición de los futuros requisitos de la IAVW. Por lo tanto, la reunión formuló la recomendación siguiente:

Recomendación 2/6 — Desarrollo ulterior de la vigilancia de los volcanes en las aerovías internacionales (IAVW)

Que un grupo de expertos apropiado de la OACI, en estrecha coordinación con la OMM, se encargue de definir de manera ulterior los requisitos para la vigilancia de los volcanes en las aerovías internacionales (IAVW) de conformidad con el Plan mundial de navegación aérea (Doc 9750), comprendida la integración de la información producida en el futuro entorno de la gestión de la información de todo el sistema (SWIM) en apoyo del sistema de gestión del tránsito aéreo interoperable a escala mundial utilizando, como base, la hoja de ruta que figura en el Apéndice C.

Meteorología del espacio

2.2.7 La reunión tomó nota del trabajo recientemente realizado por el Grupo de operaciones para vigilancia de volcanes en las aerovías internacionales (IAVWOPSG) para elaborar un proyecto de las disposiciones iniciales que se introducirían en el Anexo3/Reglamento Técnico [C3.1] con el fin de satisfacer los requisitos de información meteorológica espacial, incluyendo el establecimiento de centros de meteorología espacial. Además, la reunión tomó nota de la elaboración complementaria de un concepto de operaciones para los servicios de información sobre las condiciones meteorológicas espaciales que, como documento vivo, evolucionaría en consonancia con el GANP, en el que se incluía explícitamente la meteorología del espacio conforme a lo convenido por la 12ª Conferencia de navegación aérea (AN-Conf/12) de la OACI en 2012, y de que la información sobre las condiciones meteorológicas espaciales debía integrarse en el entorno SWIM del futuro.

2.2.8 Teniendo en cuenta el asesoramiento de la OMM, incluyendo al Equipo de coordinación entre programas sobre meteorología del espacio (ICTSW) y otros interesados, la reunión estimó que los servicios de información sobre las condiciones meteorológicas espaciales que prestan servicio a la navegación aérea internacional debían organizarse mediante el establecimiento de un número óptimo de centros mundiales (para tormentas de radiación solar y erupciones solares, al igual que para tormentas geomagnéticas y perturbaciones ionosféricas en la etapa predictiva) aumentado con un número óptimo de centros regionales (para tormentas geomagnéticas y perturbaciones ionosféricas en la etapa de observación). La reunión convino en que las funciones, requisitos y capacidades de los centros mundiales y regionales (conjuntamente con el número óptimo de centros) no se habían elaborado de manera exhaustiva. Por lo tanto, la reunión convino en que este asunto debía seguir estudiándose, incluyendo el desarrollo de un proceso para la designación de los centros mundiales y regionales, su gobernanza (comprendidas la recuperación de costos por el suministro de servicio y las normas de competencia) y la duración del mandato. Más aún, era necesario definir el entendimiento global respecto de la manera en que se utilizaría la información sobre las condiciones meteorológicas espaciales y reflejarlo adecuadamente en la documentación pertinente en relación con la meteorología del espacio.

2.2.9 Atendiendo a lo anterior, la reunión convino en que no se incluyera el proyecto de disposiciones iniciales mencionado anteriormente en el proyecto de Enmienda 77 del Anexo 3 (considerado en el marco de la cuestión 5.1 del orden del día) en vista de que era necesario seguir elaborando los requisitos y capacidades de servicio, además de textos de orientación conexos adicionales. No obstante, la reunión convino en que la OACI debía seguir trabajando para habilitar los servicios de meteorología del espacio para la aviación mediante la elaboración de disposiciones del Anexo 3 que se incorporarían en 2018 (es decir, Bloque 1). En consecuencia, la reunión formuló la recomendación siguiente:

Recomendación 2/7 — Elaboración de disposiciones relativas a información sobre condiciones meteorológicas espaciales

Que un grupo de expertos apropiado de la OACI, en estrecha coordinación con la OMM, se ocupe de elaborar disposiciones relativas a información sobre condiciones meteorológicas espaciales para la navegación aérea internacional en concordancia con el *Plan mundial de navegación aérea* (Doc 9750), comprendida la integración de la información producida en el futuro entorno de la gestión de la información de todo el sistema (SWIM) en apoyo del sistema de gestión del tránsito aéreo interoperable a escala mundial, abordando específicamente:

- a) los requisitos relativos a los servicios de información sobre condiciones meteorológicas espaciales en concordancia con el proyecto del concepto de operaciones para los servicios de información sobre las condiciones meteorológicas espaciales;
- b) los criterios de selección y la capacidad conexa para la designación de los centros mundiales y regionales de meteorología espacial, incluyendo el número óptimo de centros;
- c) la gobernanza y los arreglos de recuperación de costos apropiados para el suministro de servicios de información sobre condiciones meteorológicas espaciales a escala mundial y regional; y
- d) las consideraciones relativas al uso de la información sobre condiciones meteorológicas espaciales y las distintas repercusiones que los sucesos de meteorología espacial podrían tener en la navegación aérea internacional.

Liberación de material radiactivo

2.2.10 La reunión tomó nota de los acontecimientos significativos desde la MET/02 para la introducción de disposiciones en el Anexo 3/Reglamento Técnico [C3.1] con respecto a la difusión de información sobre la liberación de material radiactivo en la atmósfera y el desarrollo de una base de datos mundial para ayudar al Centro meteorológico regional especializado (CMRE) de la OMM situado en el mismo lugar que el VAAC de Londres (designado como centro de coordinación) en la notificación directa a los centros de control de área afectados en el caso de liberación de material radiactivo. Además, la reunión tomó nota de la elaboración de un concepto de operaciones para la información relativa a la liberación de material radiactivo en la atmósfera que, como documento vivo, debería evolucionar en consonancia con el GANP, y de que dicha información debía integrarse en el entorno SWIM del futuro. En consecuencia, la reunión formuló la recomendación siguiente:

Recomendación 2/8 — Futura elaboración de disposiciones relativas a información sobre la liberación de material radiactivo en la atmósfera

Que un grupo de expertos apropiado de la OACI, en estrecha coordinación con la OMM, se ocupe de elaborar disposiciones relativas a información sobre la liberación de material radiactivo en la atmósfera en concordancia con el *Plan mundial de navegación aérea* (Doc 9750) en evolución, comprendida la integración de la información producida en el futuro entorno de la gestión de la información de todo el sistema (SWIM) en apoyo del sistema de gestión del tránsito aéreo interoperable a escala mundial.

Otros fenómenos meteorológicos peligrosos

2.2.11 La reunión tomó nota con beneplácito del avance significativo desde la MET/02, en particular del Grupo de estudio sobre alertas meteorológicas (METWSG), con el propósito de resolver problemas de implantación que había desde hace tiempo en el suministro de información SIGMET en algunos Estados, lo cual era un impedimento para el desarrollo seguro y eficiente de las operaciones de vuelo. La reunión convino en que debía trabajarse activamente en la implantación de un sistema de avisos regional con respecto a determinadas condiciones meteorológicas peligrosas, según lo propuesto por el METWSG, para encontrar una solución de largo plazo frente a las dificultades a este respecto.

2.2.12 Además de los desafíos de carácter técnico que supone el establecimiento de este tipo de sistema de avisos regionalizado, la reunión señaló que tal vez sería necesario abordar aspectos no técnicos antes de proceder con la implantación, incluyendo gobernanza y arreglos de recuperación de costos justos. Con este fin, la reunión examinó una evaluación estratégica de las modalidades para la implantación de un sistema de avisos de condiciones meteorológicas peligrosas a escala regional y una evaluación de la gobernanza y los arreglos de recuperación de costos conexos, según figura en los Apéndices D y E, respectivamente. Asimismo, la reunión convino en que el desarrollo de este sistema de avisos debía evolucionar en consonancia con el GANP y que la información producida en el marco del sistema debía integrarse en el entorno SWIM del futuro.

2.2.13 La reunión tomó nota de que había desde hace tiempo deficiencias SIGMET en algunos Estados y de las necesidades expresadas por los usuarios en cuanto a información sobre condiciones meteorológicas peligrosas armonizada y basada en los fenómenos. A este respecto, convino en que existía una necesidad urgente demostrada por los usuarios de la aviación de establecer centros regionales de avisos de condiciones meteorológicas peligrosas (RHWAC), para ayudar a las oficinas de vigilancia meteorológica (MWO) en el suministro de información SIGMET acerca de condiciones meteorológicas peligrosas determinadas que incluyeran, como mínimo, tormentas, engelamiento, turbulencia y ondas orográficas, pero excluyendo cenizas volcánicas y ciclones tropicales (dado que existían sistemas de avisos de cenizas volcánicas y ciclones tropicales). La reunión convino en que una fase inicial de emisión de avisos a las MWO serviría en el futuro como precursora de las dos fases siguientes del desarrollo ulterior de suministro de avisos de condiciones meteorológicas peligrosas regional, según se indica en el Apéndice D mencionado.

2.2.14 Teniendo en cuenta estos requisitos de los usuarios, la reunión estuvo plenamente de acuerdo en que debía implantarse sin demora un marco relativo a las condiciones meteorológicas peligrosas a escala regional, considerando al mismo tiempo la elaboración de un marco de gobernanza y recuperación de costos.

2.2.15 La reunión convino en que el desarrollo de este sistema de avisos de condiciones meteorológicas peligrosas a escala regional debía tener el apoyo de textos de orientación apropiados para:

- a) los grupos regionales de planificación y ejecución (PIRG) de la OACI que proporcionan información técnica y capacidades de centros meteorológicos en los Estados que pueden servir de RHWAC, teniendo en cuenta la eficacia en función de los costos, como por ejemplo, la utilización de las capacidades existentes; y
- b) los Estados usuarios y los Estados proveedores de servicios en los procesos para la preparación y difusión de la información de avisos, la cooperación mutua y la sostenibilidad de la infraestructura meteorológica existente y el uso de los conocimientos especializados locales.

2.2.16 En consecuencia, la reunión formuló la recomendación siguiente:

Recomendación 2/9 — Implantación de un sistema regional de avisos para determinadas condiciones meteorológicas peligrosas en ruta

Que se encargue a un grupo de expertos apropiado de la OACI, en estrecha coordinación con la OMM, la tarea de:

- a) elaborar sin demora disposiciones para apoyar la implantación de un sistema regional de avisos basados en los fenómenos para determinadas condiciones meteorológicas peligrosas en ruta de acuerdo con el *Plan mundial de navegación aérea* (Doc 9750), atendiendo a los requisitos de larga data de los usuarios, especialmente en los Estados donde persisten deficiencias importantes relacionadas con la información SIGMET utilizando, según corresponda, las evaluaciones estratégica, de la gobernanza y la recuperación de costos que figuran en los Apéndices D y E;

- b) integrar la información producida por el sistema antes mencionado en el futuro entorno de gestión de la información de todo el sistema para apoyar la interoperabilidad mundial del futuro sistema de gestión del tránsito aéreo; y
- c) elaborar textos de orientación apropiados para apoyar los criterios de sección de centros regionales de avisos de condiciones meteorológicas peligrosas teniendo en cuenta la eficacia en función de los costos, los procesos de preparación y difusión de la información relativa a los avisos, la cooperación mutua, la sostenibilidad de la infraestructura meteorológica existente y el aprovechamiento de los conocimientos especializados locales.

Nota.— En este contexto, el concepto de determinadas condiciones meteorológicas peligrosas abarca, por lo menos, tormentas, engelamiento, turbulencia y ondas orográficas, pero excluye cenizas volcánicas y ciclones tropicales.

Información del servicio meteorológico para el área terminal

2.2.17 En relación con esto, la reunión examinó una propuesta para incluir el servicio meteorológico para el área terminal en el Bloque 1 de la metodología ASBU. La reunión tomó nota asimismo del trabajo realizado en un Estado para preparar información meteorológica adaptada a la ATM que pone de relieve las posibles repercusiones de las condiciones meteorológicas en la afluencia del tránsito aéreo y una necesidad de elaborar orientación sobre metodología de verificación que permita el mejoramiento continuo de la información meteorológica para la ATM. La reunión convino en que sería importante que se mencionaran de manera específica, en los módulos B1, comprendido el B1-AMET, de la metodología ASBU, los requisitos meteorológicos para apoyar la ATM en el área terminal, señalando que dicha adición sólo podría llevarse a cabo como parte de un examen periódico del GANP en su conjunto. La reunión tomó nota de un posible estudio que se realizaría en el marco de proyectos pertinentes de la OMM relativos al desarrollo del servicio meteorológico para el área terminal, que incluirían el impacto de las condiciones meteorológicas en los distintos aeropuertos del mundo. La reunión convino en que la experiencia adquirida con este trabajo sería verdaderamente valiosa. La reunión tomó nota asimismo de que había otros estudios en curso para determinar las necesidades de los proveedores y explotadores de servicios ATM con respecto a la información del servicio meteorológico en el área terminal. Tomando nota de las deliberaciones precedentes, la reunión formuló la recomendación siguiente:

Recomendación 2/10 — Desarrollo del servicio meteorológico para el área terminal

Que la OACI, en estrecha coordinación con la OMM, se ocupe de:

- a) incluir el servicio meteorológico para el área terminal y otros requisitos operacionales pertinentes en el Bloque 1 y bloques subsiguientes de la metodología de las mejoras por bloques del sistema de aviación para poner de relieve las posibles repercusiones conexas en la afluencia del tránsito aéreo considerando el control del tránsito aéreo y la gestión del tránsito aéreo (ATM);

- b) desarrollar servicio meteorológico adaptado a la ATM para el área terminal a fin de satisfacer los requisitos ATM futuros especificados en el *Plan mundial de navegación aérea* (Doc 9750) y reflejar los requisitos funcionales y de eficiencia apropiados en las disposiciones pertinentes, teniendo en cuenta los resultados de la labor de los grupos de expertos de la OACI, en meteorología, ATM y operaciones de vuelo;
- c) elaborar orientación sobre metodología de verificación para el mejoramiento continuo de la información meteorológica para la ATM; y
- f) integrar la información relativa al servicio meteorológico para el área terminal en el futuro entorno de gestión de la información de todo el sistema que servirá de base al futuro sistema ATM interoperable a escala mundial.

2.2.18 La reunión tomó nota con satisfacción de los mejoramientos significativos en relación con el establecimiento de un centro de meteorología para el tránsito aéreo de la Oficina meteorológica del Japón en apoyo de la ATM. En particular, la reunión tomó nota del desarrollo de un nuevo sistema para proporcionar información meteorológica específica que podría utilizarse para indicar la probabilidad de repercusiones de las condiciones meteorológicas en la afluencia del tránsito aéreo. Este sistema podría utilizarse como un índice, en el futuro, para medir el grado del impacto de las condiciones meteorológicas en el sistema ATM.

2.2.19 Adicionalmente, se informó a la reunión acerca del estudio de un caso para ilustrar la forma en que las nubes cumulonimbus en el área de aproximación del Aeropuerto internacional de Tokio afectaron significativamente a la afluencia ATC y la manera en que el centro meteorológico para el tránsito aéreo ayudó al centro ATM en la gestión eficaz y eficiente del tránsito aéreo destacando la importancia de la información sobre las condiciones meteorológicas en las áreas de control de aproximación.

Cuestión 2 del orden del día: Mejoramiento de la seguridad operacional y la eficiencia de la navegación aérea internacional mediante el suministro de servicio meteorológico perfeccionado

2.3: Mejoramiento de la información meteorológica integrada en apoyo de la toma de decisiones operacionales pre-tácticas y tácticas estratégicas a partir de 2028 (comprendido el Módulo B3-AMET de las ASBU)

2.3.1 A pesar de que el módulo B3-AMET de la metodología de mejoras por bloques del sistema de aviación (ASBU) del Plan mundial de navegación aérea (GANP) debería implantarse a partir de 2028, la reunión observó que la complejidad de la tecnología necesaria, en particular, los sistemas de gestión de vuelo y las comunicaciones por enlace de datos, implicaba que era necesario planificar cambios potencialmente significativos de los sistemas y servicios existentes y de corto plazo mucho antes del período de implantación previsto para el Bloque 3 (es decir, 2028 y después).

2.3.2 Por consiguiente, la reunión convino en que era necesario que, muchos años de la fecha de implantación prevista de 2028, empezaran a considerarse los requisitos tecnológicos y las capacidades de servicio contenidas en el Bloque 3 de las ASBU, en particular, los del módulo B3-AMET y de los otros módulos relacionados con la gestión de la información de todo el sistema (SWIM). En consecuencia, la reunión formuló la recomendación siguiente:

Recomendación 2/11 — Planificación anticipada del componente de meteorología aeronáutica del Bloque 3 de las ASBU

Que un grupo de expertos apropiado de la OACI, en estrecha coordinación con la OMM, se ocupe, durante el período de 2015 a 2020, de la planificación anticipada de los requisitos tecnológicos y las capacidades de los servicios de meteorología aeronáutica necesarios en apoyo de la implantación en 2028 del módulo B3-AMET de la metodología de mejoras por bloques del sistema de aviación (ASBU) y los componentes meteorológicos de otros módulos ASBU relacionados con la gestión de la información de todo el sistema contenidos en el *Plan mundial de navegación aérea* (Doc 9750).

2.3.3 La reunión examinó los cambios propuestos respecto del sistema mundial de pronósticos de área (WAFS) en el plazo del Bloque 3, que debían centrarse en los principios contenidos en el Apéndice F. Una vez finalizado el examen y reconociendo que era particularmente difícil prever plenamente el estado futuro del sistema de aviación (y del componente WAFS) en el plazo de 2028, la reunión convino en que los principios se utilizaran como base del desarrollo futuro del WAFS en apoyo del módulo B3-AMET de la metodología ASBU. En consecuencia, la reunión formuló la recomendación siguiente:

Recomendación 2/12 — Desarrollo del WAFS en apoyo de las mejoras por bloques del sistema de aviación (ASBU) después de 2028

Que la OACI utilice los principios descritos en los resultados esperados para las operaciones en ruta contenidos en el Apéndice F como base para el desarrollo futuro del sistema mundial de pronósticos de área (WAFS) en apoyo del módulo B3-AMET de la metodología ASBU.

Cuestión 2 del orden del día: Mejoramiento de la seguridad operacional y la eficiencia de la navegación aérea internacional mediante el suministro de servicio meteorológico perfeccionado

2.4: Toma de decisiones en colaboración y conciencia situacional común — consideraciones de automatización y factores humanos

2.4.1 La reunión tomó nota de los beneficios previstos que se obtendrían con la aplicación de la toma de decisiones en colaboración (CDM) en un entorno operacional rico en información. A este respecto, se consideraba que la CDM era un aspecto fundamental para determinar la forma en que el sistema de gestión del tránsito aéreo (ATM) mundial maduraría, garantizando que las decisiones sean informadas, comprendidas por todos y basadas en la evaluación compartida de la información subyacente. Asimismo, se tomó nota de que, como la meteorología aeronáutica era un componente integral del conjunto total de información disponible a partir del cual la comunidad ATM tomaría decisiones operacionales en colaboración, se desprendía que la meteorología aeronáutica sería un habilitante clave de conciencia situacional común.

2.4.2 La reunión recalcó que en este entorno de colaboración había una gran necesidad de gobernanza, incluyendo la gestión de la calidad y la normalización de los datos para los que había formatos de datos prescritos que eran comunes en todos los ámbitos de información en el entorno futuro de la gestión de la información de todo el sistema (SWIM) de la ATM mundial.

2.4.3 La reunión tomó nota de que la transición prevista de un suministro de servicios centrado en productos a un suministro centrado en la información o datos suponía inevitablemente menos interacción con la información meteorológica aeronáutica (de la parte de los proveedores y los usuarios) debido al mayor grado de automatización. Además, considerando este entorno operacional automatizado y reconociendo la singularidad de las decisiones operacionales de los usuarios, la reunión convino en que sería conveniente no ser prescriptivo con respecto a las normas de visualización de la información meteorológica aeronáutica comúnmente disponible, ya que cada usuario tendría sus propias, y a menudo singulares, necesidades y capacidades operacionales.

2.4.4 La reunión tomó nota de que, con el fin de maximizar la interoperabilidad y facilitar el proceso de implantación, los proveedores de servicios de navegación aérea (ANSP), como miembros clave de la comunidad ATM, desempeñarían una función integral en la transición de las comunidades de la meteorología aeronáutica y la ATM hacia un entorno centrado en la información.

2.4.5 La reunión convino en que la transición a un entorno operacional más cooperativo y más automatizado requeriría modificar la forma en que la información meteorológica aeronáutica se ponía a disposición de los usuarios y la manera en que ellos la aplicaban, y en que la gobernanza era un prerrequisito. Además, era necesario garantizar que las consideraciones de factores humanos siguieran siendo un elemento integrante del suministro de servicio meteorológico aeronáutico durante y al finalizar la transición. En consecuencia, la reunión formuló las recomendaciones siguientes:

Recomendación 2/13 —Elaboración de disposiciones para los servicios de información meteorológica aeronáutica en el contexto de la CDM y la conciencia situacional común

Que la OACI y la OMM garanticen la elaboración de disposiciones para los servicios de información meteorológica aeronáutica que promuevan la toma de decisiones en colaboración (CDM) y la conciencia situacional común en la comunidad de la gestión del tránsito aéreo (ATM).

Recomendación 2/14 — Consideraciones de factores humanos para la elaboración de disposiciones sobre servicios meteorológicos aeronáuticos

Que la OACI y la OMM garanticen que las consideraciones de factores humanos sean un aspecto central en el desarrollo de los servicios de información meteorológica aeronáutica.

2.5 Declaración de las Delegaciones de China y la Federación de Rusia

Sistema mundial de pronósticos de área (WAFS)

2.5.1 El desarrollo del WAFS debería situarse en su debida perspectiva histórica. Se sabe que el establecimiento del WAFS en 1982 se basaba en la situación de entonces, en que no todos los Estados contaban con capacidad de predicción meteorológica numérica (NWP) y difusión por satélite. Sin embargo, la situación mundial ha cambiado significativamente durante los últimos tres decenios y numerosos Estados utilizan hoy sistemas NWP con grandes escalas espaciales y temporales que alcanzan hasta una semana o más. Al mismo tiempo, las tecnologías de difusión por satélite dejaron de ser rentables en comparación con Internet. Por consiguiente, si se excluyen los pronósticos del modelo WAFS, existen numerosos otros modelos de pronósticos mundiales que podrían utilizarse para fines de planificación de vuelo en ruta, a condición de que satisfagan un nivel requerido de rendimiento y se designen a nivel internacional.

2.5.2 Con el ingente crecimiento del tráfico aéreo en el mundo entero, en particular en la región Asia-Pacífico, aumenta la demanda de los usuarios en materia de mejores pronósticos y enmiendas más oportunas de la información SIGWX para responder a los rápidos cambios en las condiciones meteorológicas, tales como una convección significativa que los centros mundiales existentes no hayan pronosticado. Además, en el futuro entorno SWIM, en que se dependerá en mayor grado de pronósticos reticulados para apoyar ATM y TBO, no parece evidente que el actual WAFS pueda satisfacer las futuras necesidades de los usuarios. A fin de hacer frente al crecimiento inevitable del tráfico aéreo, los centros existentes deben satisfacer las demandas crecientes de los usuarios, que tal vez no se satisfagan eficazmente mediante el arreglo actual que se limita a dos centros mundiales. Se juzga pertinente reconsiderar la función y papel de los WAFS en el nuevo contexto del GANP y la metodología ASBU. Así, al examinar los centros mundiales, deberían considerarse los aspectos relativos a rendimiento, equidad y sostenibilidad, incluidas las disposiciones de apoyo. Debería brindarse a los usuarios la posibilidad de seleccionar el modelo mundial que mejor satisfaga sus necesidades operacionales.

2.5.3 Además, el Anexo 3 y los futuros PANS-MET deberían reglamentar el suministro de servicio meteorológico, incluidos los pronósticos WAFS, o sea, fijar las normas de rendimiento requeridas que cada servicio debería satisfacer, en lugar de los organismos que suministran dicho servicio.

2.6 Declaración de las Delegaciones de Bahrein, Emiratos Árabes Unidos, Kuwait y Qatar

A los Secretarios Generales de la OACI y la OMM

2.6.1 Con referencia al apoyo al concepto de “cielo único” por la Reunión Departamental de Meteorología MET/14 en relación con el Plan mundial de navegación aérea (GANP) y el componente meteorológico de la metodología de las mejoras por bloques del sistema de aviación (ASBU), la representación subregional en la Reunión Departamental de Meteorología/14 de la OACI (integrada por Bahrein, Emiratos Árabes Unidos, Kuwait y Qatar) desea señalar a su atención las inquietudes indicadas a continuación.

2.6.1.1 En relación con el proyecto de recomendación que figura en el párrafo 2.5.6 de la nota MET/14-WP/6|CAeM-15/Doc. 6, relativo a la Implantación de un sistema regional de avisos para determinadas condiciones meteorológicas peligrosas en ruta, y con los Apéndices B y C, nos permitimos señalar a su atención que la implantación de un sistema regional de avisos para suministrar información SIGMET tendría repercusiones en:

- a) la función subregional de suministro de avisos SIGMET como proveedores de servicios y la viabilidad de la organización de los servicios meteorológicos e hidrológicos nacionales (NMHS) en la subregión;
- b) la manera precisa en que se asumen las responsabilidades de la subregión suministrando, de manera competente, avisos SIGMET desde 1960;
- c) las inversiones actuales y continuas en recursos humanos y sistemas meteorológicos; y
- d) el cobro de derechos como se indica en los párrafos 5.2.1.3 y 5.2.1.4 del Apéndice C de la nota MET/14-WP/6|CAeM-15/Doc. 6.

2.6.2 En conclusión, todos los mencionados países solicitan a la OACI y la OMM que consideren las recomendaciones propuestas por la subregión dados los efectos previstos en su función rectora en calidad de proveedor regional único al sistema internacional controlado. Todos los mencionados países han estado suministrando, desde hace más de un decenio, servicios meteorológicos valiosos, de calidad y eficientes a las comunidades de aviación en materia de alerta meteorológica temprana. Nuestra subregión ha invertido en sistemas meteorológicos para suministrar servicio SIGMET por intermedio de sus FIR asignadas aplicando planes de inversiones continuas como contribución a la presentación radar en mosaico, la predicción meteorológica numérica (NWP) en los sectores atmosférico y oceánico, la recepción de datos radar y la redistribución subregional. Considerando todas esas inversiones, nuestra capacidad de mantener y sostener dichas infraestructuras se encuentra amenazada debido al nuevo entorno SWIM regionalizado; además, se nos impone una postura en que podríamos perder nuestra función visible ante otros miembros, así como el apoyo de nuestros gobiernos.

2.6.3 Además de las circunstancias propias de nuestra región, solicitamos a la OACI y la OMM que precisen claramente los reglamentos (respecto a acuerdos bilaterales) y las reglas que deben establecerse antes y en el momento de asignar el suministro de servicios SIGMET regionales.

APÉNDICE A

RESULTADOS ESPERADOS DEL SISTEMA MUNDIAL DE PRONÓSTICOS DE ÁREA EN APOYO DEL BLOQUE 0 DE LAS ASBU

- Implantación de algoritmos mejorados para turbulencia, incluido el reemplazo del potencial de turbulencia por la gravedad de la turbulencia [es decir, el régimen de disipación de los remolinos (EDR)]
- Implantación de algoritmos mejorados para engelamiento, incluido el reemplazo del potencial de engelamiento por la gravedad del engelamiento
- Verificación mundial y regional de los pronósticos del WAFS utilizando los datos proporcionados por los Estados y organizaciones usuarios.

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APÉNDICE B

RESULTADOS ESPERADOS DEL SISTEMA MUNDIAL DE PRONÓSTICOS DE ÁREA EN APOYO DE LOS BLOQUES 1 Y 2 DE LAS ASBU

Los cambios previstos en el período del módulo B1-AMET - *Información meteorológica para mejorar la eficiencia y seguridad operacionales* (2018-2028) son:

- 2018-2023:
 - Implantar sistema de predicción basado en conjuntos de nubes cumulonimbus
 - Implantar pronósticos de tipos de turbulencia (por ejemplo, actividad convectiva, cizalladura por corriente en chorro, terreno) utilizando el régimen de disipación de los remolinos (EDR)
 - Implantar un reticulado de mayor resolución para los datos del WAFS
 - Implantar pronósticos probabilísticos calibrados para engelamiento, turbulencia y nubes cumulonimbus
 - Suministrar un conjunto parcial de datos relativos a información meteorológica que se pueda incorporar en los sistemas de apoyo para la toma de decisiones en materia de planificación de vuelos, gestión de vuelos y gestión del tránsito aéreo (ATM) para fenómenos meteorológicos en ruta
 - Implantar pronósticos de tiempo significativo (SIGWX) en formato XML/GML para reemplazar los SIGWX en formato BUFR
 - Publicar datos del WAFS mediante la gestión de la información de todo el sistema (SWIM)
- 2023-2028:
 - Suministrar un conjunto más amplio de datos relativos a información meteorológica que permita incorporar esa información en los sistemas de apoyo para la toma de decisiones en materia de planificación de vuelos, gestión de vuelos y ATM para fenómenos meteorológicos en ruta.

Mejora de los algoritmos

Entre las mejoras logradas por los WAFC, cabe mencionar:

- Nube cumulonimbus:
 - Mejoras relativas al sistema de convección y uso de pronósticos basados en conjuntos
 - Cambio de parámetros de la información para brindar valores calibrados más útiles

- Turbulencia:
 - Caracterización de tipo de turbulencia, por ejemplo, convectiva, cizalladura del viento de niveles altos o inducida por el terreno
 - Información probabilística calibrada utilizando EDR
- Englamiento:
 - Información probabilística calibrada

APPENDIX C

Roadmap
for
International Airways Volcano Watch (IAVW)
in
Support of International Air Navigation

21 November 2013

Version 1.0

Revision	Date	Description
0.1	29 July 2013	Initial draft. Based on draft ConOps for the IAVW in response to IAVWOPSG Conclusion 7/17. Aligns with <i>Meteorological Information Supporting Enhanced Operational Efficiency and Safety</i> from ICAO's Aviation System Block Upgrades (ASBU).
0.2	27 September 2013	Revised draft based on comments from IAVWOPSG ad hoc group.
0.3	24 October 2013	Revised draft based on comments on version 0.2 from the IAVWOPSG ad hoc group.
0.4	10 November 2013	Revised draft based on comments on version 0.3 from the IAVWOPSG ad hoc group
1.0	19 November 2013	Submitted to IAVWOPSG Secretariat
1.0 rev	21 November 2013	Revised to include additional comments from WMO

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Preface

At the first meeting of the International Volcanic Ash Task Force (IVATF/1), held at ICAO Headquarters in Montréal from 27 to 30 July 2010, it was recognized that there was a need to further promote and improve the services provided by Volcanic Ash Advisory Centres (VAAC) and Meteorological Watch Offices (MWO). It was agreed that a global Concept of Operations (ConOps) for volcanic ash should be developed that would cut across all service fields from a perspective of the providers of information to the users/operators of that information in support of both tactical and strategic decision making. This resulted in IVATF Task TF-VAA10, *Development of a Concept of Operations for the International Airways Volcano Watch (IAVW)*.

A draft version, and follow-on revisions, of the ConOps for volcanic ash were presented to the IVATF at their subsequent meetings. At the IVATF's fourth meeting the IAVW Operations Group (IAVWOPSG) was tasked with developing a version 1.0 of the ConOps, and this was subsequently presented to the seventh meeting of the IAVWOPSG (Bangkok, Thailand, 18-22 March 2013). At that meeting the group recognized the inherent value of the ConOps document and agreed to use the material included in the ConOps for the development of an IAVW roadmap to be consistent with the outcomes of ICAO's 12th Air Navigation Conference (Montreal, Canada, November 2012) and formulated Conclusion 7/17 which states:

Conclusion 7/17— Development of an IAVW roadmap

That an ad-hoc group consisting of Canada, China, France, Germany, New Zealand, United Kingdom, United States (Rapporteur), IATA, ICCAIA, and WMO to be tasked to:

- a) develop an IAVW roadmap for the provision of information services in support of the aviation system block upgrade (ASBU) methodology to be included in ICAO's Global Air Navigation Plan, taking into consideration the draft concept of operations for the IAVW as presented in Appendix J to this report; and
- b) provide a draft of the roadmap called for by a) above by 29 November 2013 for onward consideration at the IAVWOPSG/8 meeting and the proposed ICAO MET Divisional Meeting in July 2014.

This roadmap replaces the ConOps as originally proposed and is a living document that will evolve as the science and technology improves, and as operational requirements evolves.

1.0 Introduction/Scope

The roadmap for the International Airways Volcano Watch (IAVW) is based on the draft Concept of Operations (ConOps) for the IAVW which was presented at the seventh meeting of the IAVW Operations Group (IAVWOPSG/7). This roadmap replaces the ConOps.

The roadmap is not intended to provide detailed descriptions on all the areas presented in the document, rather it presents a high-level overview for the user.

1.1 Purpose

This document is intended to provide international air navigation users and providers of information under the IAVW with a roadmap that defines improved services including the integration of volcanic meteorological information into decision support systems for trajectory based operations (TBO).

This document provides a plan for the development and implementation of volcanic meteorological information for modules *B1-AMET* and *B3-AMET*, time frames 2018 and 2028 respectively¹.

Module *B0-AMET*² of ICAO's Aviation System Block Upgrades (ASBU), titled *Meteorological Information Supporting Enhanced Operational Efficiency and Safety*, describes the baseline of meteorological information provided in Block 0 of the ASBU which is defined as beginning in 2013. The IAVW element is included in module *B0-AMET* and describes the information services provided by State Volcano Observatories (VO), Meteorological Watch Offices (MWO) and Volcanic Ash Advisory Centers (VAAC).

1.2 Background

The Eyjafjallajökull volcanic eruption of April and May 2010 highlighted issues relating to all aspects of volcanic ash service provision including underpinning science and observational capabilities. Eyjafjallajökull brought direct attention to the need for a better understanding of volcanic ash information and the use of that information in Air Traffic Management (ATM) and flight operations. In addition it was recognized that there were no measureable certificated tolerances for volcanic ash for safe and permissible aircraft operations.

While the provision of contemporary volcanic ash information has served the international community well for many years, especially in areas where the airspace is not congested and operators have greater flexibility in avoiding airspace identified with ash, the application of this operational procedure did not work well in congested airspace. This was evident from the Eyjafjallajökull volcanic ash episode in April and May of 2010. During this time period, volcanic ash of mostly unknown concentrations, were detected visually and/or by satellite imagery at times over parts of Western Europe and parts of the North Atlantic. This was due to the

¹ Module *B1-AMET* encompasses the timeframes of Block 1 (2018) and Block 2 (2023).

² Advanced Meteorological Information (AMET).

prevailing meteorological conditions and the prolonged period of eruption. The busy and congested air routes over Europe were significantly impacted and issues also arose with the many Air Navigation Service Providers (ANSP) and MWOs serving a multitude of Flight Information Regions (FIRs). At one time during the Eyjafjallajökull eruption, more than 40 volcanic ash SIGMET messages were in effect.

The limited ability to identify observed areas of volcanic ash as well as forecast areas of volcanic ash concentrations hazardous to aircraft was another significant factor in the resultant closing of airspace, especially during the first few days after the initial eruption.

Aviation users (i.e. ANSP, operators and pilots) need to know the location, size and vertical extent of a given volcanic cloud, and where it will be located in the future. Ideally, the precise location and future location of the volcanic ash cloud would be known with great accuracy and confidence and over time scales ranging from minutes to days. However, the current science for observing and forecasting volcanic ash cannot provide that precision or accuracy.

Currently there are no requirements to observe and forecast volcanic gases, such as sulphur dioxide (SO₂), thus these observation and forecasts do not exist. However, Grímsvötn (2011) highlighted shortfalls in our understanding of and service provision for possible SO₂ impacts.

Aviation users need to know how much volcanic ash is in the atmosphere and if those amounts pose a threat to the aircraft's engine(s) and system(s). However, there are no agreed values of ash which constitute a hazard to an aircraft.

In addition, many volcanoes are not monitored despite continued efforts from the International Union of Geodesy and Geophysics (IUGG), ICAO and WMO. The lack of this monitoring contributes to uncertainty in the model output in that the source data from the eruption is based on an estimate.

1.3 Problem Statement

Explosive volcanic eruptions eject pulverized rock (volcanic ash) and corrosive/hazardous gases high into the atmosphere. Depending on the energy and duration of an eruption, there is potential for an ash cloud to cover a wide area for timescales ranging from hours to days.

Volcanic eruptions represent a direct threat to the safety of aircraft in flight and present major operational difficulties at aerodromes and in airspaces located proximal to volcanoes. Currently there are no agreed values of ash loading metrics (amount and rate of ash ingestion) that represent quantified hazard to aircraft or gas turbine engines. The exposure time of aircraft or engines to the ash, type of ash and the thrust settings at the time of the encounter, both have a direct bearing on the threshold value of ash loading that may constitute a hazard. Hence, the current globally recommended procedure is to avoid any volcanic ash, regardless of the level of ash contamination. Many years of service have demonstrated this to ensure safe operation.

In order to improve efficiencies in air transportation during volcanic events, quality, timely and consistent volcanic ash information (observations and forecasts) are essential to mitigate the safety risk of aircraft encountering volcanic ash. Education of all users (operators and ATM) is also needed to ensure proper use of volcanic ash information within the operator's risk assessment process.

If demonstrated to be beneficial and without compromising safety, it may be desirable to agree to standards on where and for how long aircraft can operate in specified concentrations. Until those standards are established, if indeed they can be, considerable effort is required to establish rigorous and well understood practices and products provided by the VAACs.

1.4 Identification

This roadmap is expected to provide the guidance on services tasked by the IVATF and the ICAO challenge team and identified in the ICAO's ASBUs. This document will be updated as required as procedures changes or as technology warrants a change to take advantage of new state of the art capabilities to detect, monitor, and forecast ash.

This document is intended to complement the ICAO *ATM Volcanic Ash Contingency Plan*, ICAO Doc 9974 *Flight Safety and Volcanic Ash*, ICAO Doc 9691 *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds*, and ICAO Doc 9766 *Handbook on the International Airways Volcano Watch*.

2.0 Current Operations and Capabilities

During a volcanic event the coordination and flow of information regarding the location and forecast position of the volcanic cloud is the primary concern. It involves cooperation among all information providers in support of operational decision makers. Providers of information primarily include MWO, VAACs, and VOs. Users of information are ANSPs that include Aeronautical Information Services (AIS), Air Traffic Control (ATC) and Air Traffic Flow Management (AFTM) units, flight crews, and airline operations centers (AOC). The cooperation between operators and civil aviation authorities (CAA) using the information provided by the providers is essential for the purpose of supporting the pre-flight process, and the in-flight and post-flight decision-making process, as part of the risk mitigation in accordance with ICAO Doc 9974 *Flight Safety and Volcanic Ash*.

2.1 Description of Current Operations

Services in support of the provision of meteorological information for volcanic events can be categorized in four areas: (1) monitoring the threat, onset, cessation, dimensions and characteristics of an eruption, (2) monitoring the volcanic ash in the atmosphere, (3) forecasting the expected trajectory and location of the ash cloud, and (4) communicating the information to the users.

2.1.1 Monitoring the threat, onset, cessation, dimensions and characteristics of an eruption

The ability to provide an advanced warning of an imminent eruption and the onset of the eruption rests with the VOs which are loosely organized under the banner of the World Organization of Volcano Observatories (WOVO) of the International Union of Geodesy and Geophysics (IUGG). These VOs provide guidance on the magnitude of the eruption, including dimensions and characteristics, which are then used in support of numerical dispersion and transport models.

Pre-eruptive activity may come from several sources, including, but not necessarily limited to: seismic monitors, physical observations of deformation, hydrologic activity, gaseous activity, steam explosions, or debris flow. The international aviation community has established a four-level color code chart for quick reference to indicate the general level of threat of an eruption for a given volcano. The color codes identify the state of the volcano (i.e. pre-eruptive vs. eruptive stage)³ and not to ash in the atmosphere. While the international community has developed the color code chart, it should be noted that these codes are not assigned to all volcanoes for various reasons.

In 2008, the IAVWOPSG agreed to implement a message format to assist volcanologists in the provision of information on the state of a volcano in support of the issuance of volcanic ash advisories (VAA) by VAACs, and the issue of SIGMET information by MWOs, and the issuance of a Notice to Airmen (NOTAM) for volcanic ash by Air Traffic Services (ATS). The message, referred to as Volcano Observatory Notice for Aviation (VONA), was introduced into the ICAO *Handbook on the International Airways Volcano Watch*, Doc 9766. The VONA should be issued by an observatory when the aviation color code changes (up or down) or within a color code level when an ash producing event or other significant change in volcanic behavior occurs. The VONA allows the volcanologists to provide a succinct message on the state of volcano to MWO, VAAC, and ACC which as noted above assists in the issuance of SIGMET, VAA and NOTAM respectively.

For safety purposes, operators have stated the importance of having available pre-eruption activity for situational awareness. Some VOs and a VAAC⁴ currently provide information the volcanic activity within their area of responsibility. This is expected to be extended so that all volcanic areas have improved activity reporting for aviation and is a task being looked at by the IAVWOPSG⁵.

³ In the aviation volcano color code; Green denotes a non-eruptive state; Yellow denotes a state of elevated unrest; Orange denotes a state of heightened unrest with the likelihood of eruption, or minor eruption underway; and Red denotes a forecast of imminent major eruption, or that major ash-producing eruption is underway.

⁴ The Darwin VAAC provides a daily volcanic activity summary on the volcanoes in their area of responsibility.

⁵ IAVWOPSG Conclusion 7/13 refers.

2.1.2 Volcanic ash-cloud monitoring

Depending on many variables, an ash cloud can be detected from the ground, air, or from satellite. A large number of different ground and air-based instruments are available to monitor volcanic ash clouds, including lidar, ceilometers, sun photometers, radar, imaging cameras and aerosol sondes. However, none of these are yet designed, networked or quality controlled for operational use and many are operated in ad-hoc research mode only⁶. Satellite-based sensors are used to locate ash cloud and aid in discerning the perimeter of ash clouds. Ash clouds can be detected on visible satellite imagery, but only during the day. Single and multi-spectral infrared imagery and applied techniques can be used both day and night, and can provide a means of estimating the top of the ash cloud and in the case of the multi-spectral Meteosat SEVERI sensor ash cloud composition characteristics including mean particle size and ash mass loading estimates. Both visible and infrared imagery have limitations when meteorological clouds (e.g., cirrus, etc.) are present depending on the thickness and height of the meteorological cloud cover. Infrared measurements can only detect volcanic ash if the ash is the highest cloud layer, regardless of the level of ash contamination.

Until recently, what was detected by satellite was assumed or interpreted by many to be the “visible ash cloud.” This term was also used to refer to ash clouds seen by pilots in the air and people on the ground. To avoid further confusion and misuse of terms, the IAVWOPSG formulated Conclusion 7/16 which defined “visible ash” and “discernible ash”. According to Conclusion 7/16:

- visible ash be defined as “volcanic ash observed by the human eye” and not be defined quantitatively by the observer
- discernible ash be defined as “volcanic ash detected by defined impacts on/in aircraft or by agreed in-situ and/or remote-sensing techniques”

It is noted that there is no single quantitative threshold value for ‘visible ash’. Discernible ash agreed in-situ and/or remote-sensing techniques are based on the findings and recommendations of the IUGG/WMO Volcanic Ash Scientific Advisory Group.

2.1.3 Volcanic ash forecasts

Today’s volcanic ash forecasts are basic textual and graphical products derived and produced using the output from dispersion and transport models validated and amended against available volcanic ash observations. Most of the numerical models utilized by VAACs depend on meteorological input (e.g. wind speed and direction) as well as input regarding the eruptive parameters at the volcanic source (Eruption Source Parameters - ESP). ESPs include (1) plume height, (2) eruption duration or start/stop time, (3) mass eruption rate, (4) fraction of fine ash particles, and (5) the vertical distribution of mass with height above the vent. Uncertainty or

⁶ In 2012 WMO had established the GALION activity as a network (see also www.dwd.de/ceilomap) with a focus also on operational volcanic ash monitoring. This European network already now consists of several thousand systems, for which algorithms have been developed to get quantified volcanic ash information in a quality much better than (passive) satellite observation, although the location of systems is certainly restricted to continental (land-surface) stations.

inaccuracy in any of the various sources can result in large errors in the resultant volcanic ash forecasts.

Forecasters provide value added input to the model output as required before issuing a VAA and VAG. This work is dependent on real-time verification of the ash cloud model output against a range of observational resources, principally, remote sensing by satellite.

Today's two primary volcanic ash forecast products are the VAA and the SIGMET. The VAA is produced and issued by the VAAC, and the SIGMET is produced and issued by the MWO. The VAAC provides the VAA in a text and/or graphic-based format (the graphic version of the VAA is referred to as a VAG), that provides an analysis of the ash cloud and a 6, 12 and 18-hour forecast on the trajectory of the ash cloud and the associated flight levels that may be affected. The VAAs are produced and issued by nine VAACs across the world, each with a defined geographical area of responsibility, as shown in Figure 1. MWOs issue volcanic ash cloud SIGMETs based on the guidance provided by the associated VAAC. These SIGMETs are valid for up to six hours and describe the location and expected location of the ash cloud within the FIR or area of responsibility of the MWO.

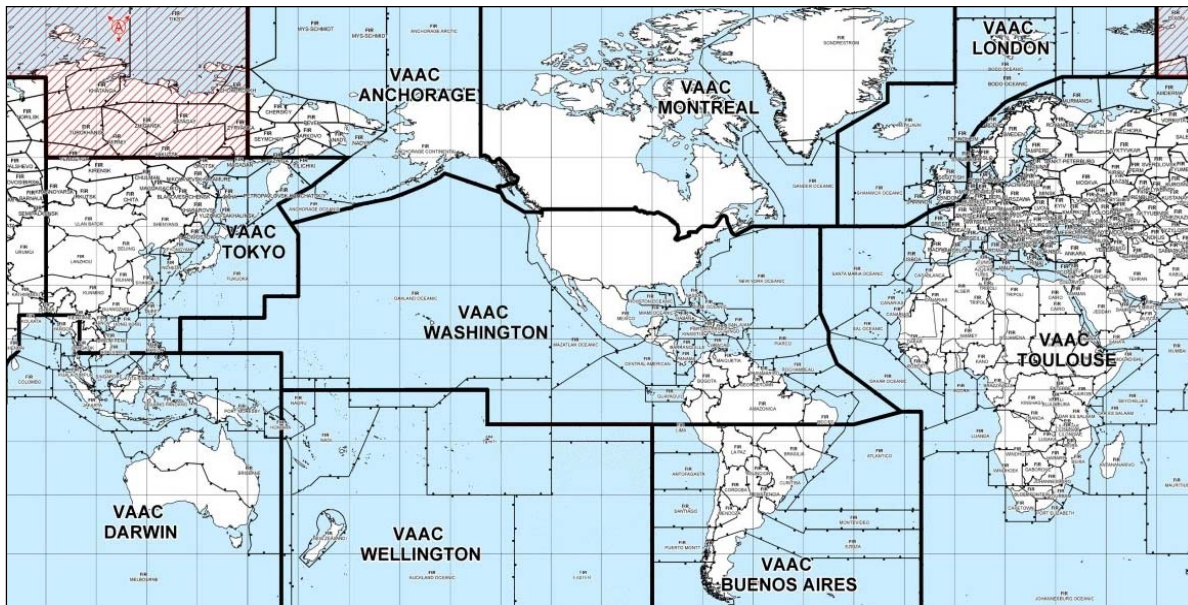


Figure 1. Areas of responsibility for the nine VAACs.

As a supplementary service, meteorological (MET) offices collocated with the EUR/NAT VAACs are required by regional documentation to issue forecast ash concentration charts. Such charts, depicting forecast ash concentration were first provided to users in April 2010 in response to the Eyjafjallajökull volcanic event. It is important to note that there are no globally agreed standards and procedures for the production and provision of such information. Despite lack of global requirement and large uncertainties the ICAO EUR/NAT Volcanic Ash Contingency Plan still includes the provision and use of such charts to underpin the current airlines volcanic ash safety risk assessments.

2.1.4 Communicate volcanic ash information to users

In the simplest terms, MET services are required to provide volcanic ash information to airline operators and ANSPs who then pass the information to aircraft and pilots. Figure 2 depicts an example of information flow following a volcanic eruption. The Figure identifies participants in the provision of contemporary volcanic ash cloud information. The lines between the providers in the diagram do not imply one-way communication, or communication relationships. The lines represent the distribution of information over aeronautical fixed services, with the exception of the VONA⁷. The box colors do not represent significance; rather they help distinguish the information products (e.g., observations and forecasts) (red) from the providers/users (shades of blue, purple and green).

The initial report of volcanic ash can result in many products being delivered to the end user. In most cases, information about a volcanic ash cloud will be provided to the pilot, either in-flight, or during pre-flight planning, in the form of a SIGMET, NOTAM or ASHTAM⁸, Special AIREP, or VAA. Each of these products is unique in format and content, but all provide information regarding the location of the volcanic ash. It is critically evident that all of these products must be consistent in their overall message.

⁷ VOs disseminate the VONA via facsimile or e-mail.

⁸ ASHTAM is a special series NOTAM for a volcanic eruption and/or volcanic ash cloud.

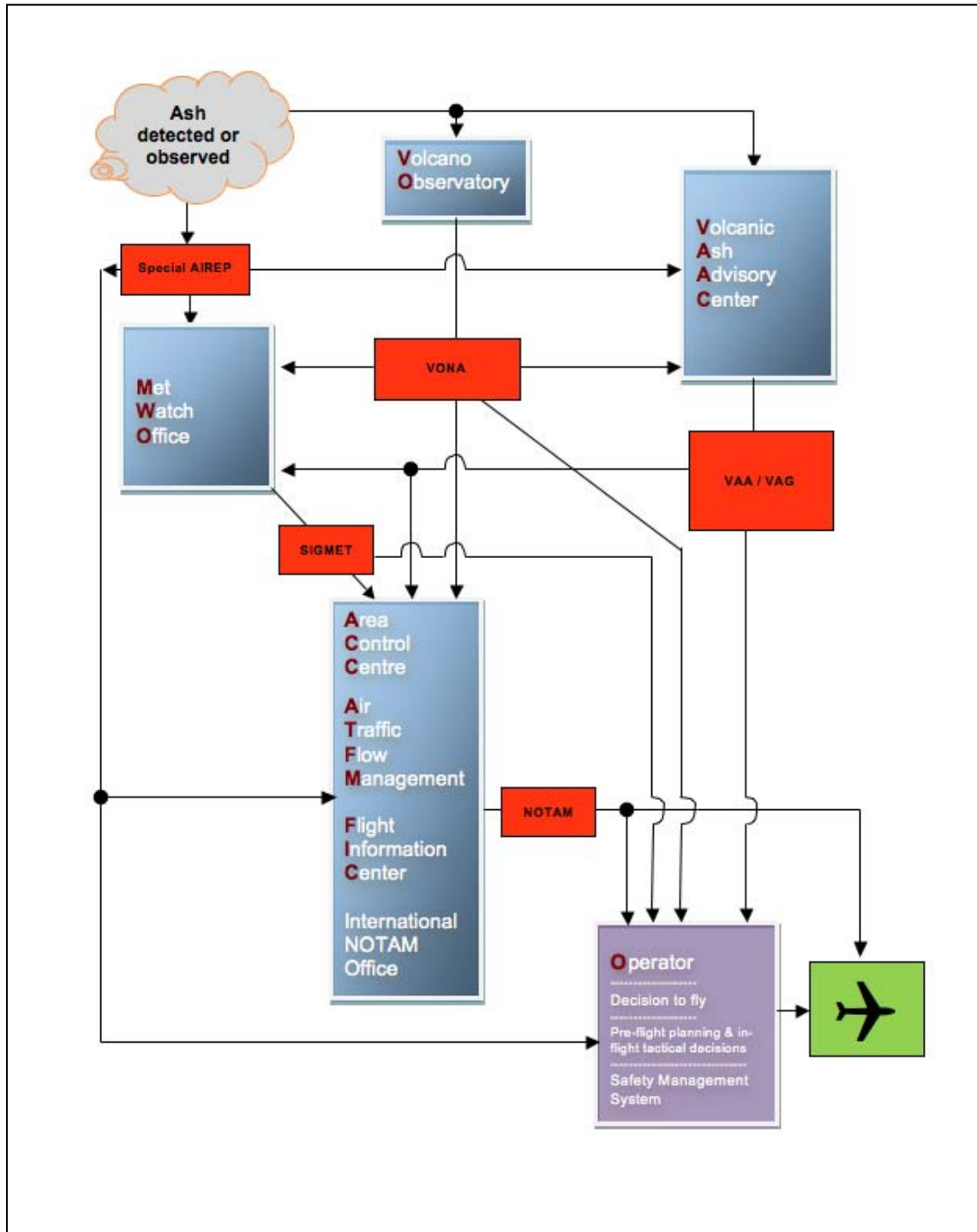


Figure 2. High-level information flow diagram between the users and providers of contemporary volcanic ash cloud information. The lines represent the distribution of information over aeronautical fixed services, with the exception of the VONA. The box colors do not represent significance; rather they help distinguish the information products (e.g., observations and forecasts) (red) from the providers/users (shades of blue, purple and green). It should be noted that there are other distribution networks and information sources that may be unique to different States which are not depicted in the diagram.

2.2 Current Supporting Infrastructure

Table 1 outlines service providers and their functions with respect to volcanic cloud information. The exact role of each provider depends on various circumstances that are not exhaustively described in the table.

Current Services and Providers		Functions for:			Information	
		Pre-Eruption	Eruption ⁹	Volcanic Ash ¹⁰	Information Received and Used	Information Provided (shared)
Volcano Observatory (VO)		Monitor volcano, report changes in status. Pre-eruption activity for situational awareness	Monitor eruption, report changes in status.	Monitor and report	Data from ground-based, air-based and satellite-based observing networks.	VONA
MET Service Provider	Met Watch Office (MWO)		Provide location and notice of eruption	Provide location and dimension of volcanic ash	AIREP, VONA (report from VO), VAA/VAG, METAR/SPECI, NOTAM. Data from ground-based, air-based, satellite-based observing networks. Input from VAACs and other research institutes.	SIGMET
	Aerodrome Met Office and Stations	Report pre-eruption activity	Report	Report		METAR/SPECI. Aerodrome Warning
	Volcanic Ash Advisory Center (VAAC)	Pre-eruption activity for situational awareness.	Initial analysis including dispersion model (initialization), forecast and coordination.	Determine and predict location and dimensions of airspace impacted by volcanic ash	VONA (report from VO). Data from ground-based, air-based, satellite-based observing networks. Input from other VAACs and other research institutes.	VAA and VAG
	Other State, Research, University, Commercial Services (including research modeling centers)	Coordinate with VO and VAACs	Initialize dispersion model. Operate aircraft and sondes for airborne sampling of ash. LIDAR etc for ground based sampling.	Produce model derived predictions of volcanic ash. Operate aircraft and sondes for airborne sampling of ash. LIDAR etc for ground based sampling.	Data from ground-based, air-based, satellite-based observing networks. ESP.	Deliver model derived predictions

⁹ Known as the “Start of Eruption” cycle in Doc 9974 - ICAO Doc 9974 *Flight Safety and Volcanic Ash*.

¹⁰ Same as the “Ongoing Eruption” cycle in Doc 9974 ICAO Doc 9974 *Flight Safety and Volcanic Ash*.

Current Services and Providers		Functions for:			Information	
Service Provider		Pre-Eruption	Eruption ⁹	Volcanic Ash ¹⁰	Information Received and Used	Information Provided (shared)
Air Navigation Service Provider (ANSP)	Air Traffic Control Units (Area, Approach, Aerodrome)	Identify appropriate areas ¹¹ within airspace to outline hazard	Identify appropriate areas within airspace to outline hazard. Reroute traffic as necessary	Identify appropriate areas within airspace to outline hazard. Reroute traffic as necessary	SIGMET, NOTAM/ASHTAM, VAA/VAG, VONA or report from VO, VAR (Special AIREP)	IFR clearances. FIR's sector capacity. Affected aerodrome arrival and departure acceptance rate
	Air Traffic Management (ATM)	Maintain communications links and ATS monitoring systems	Implement contingency plans	Lead CDM process for adjusting traffic capacity and routes	SIGMET, NOTAM/ASHTAM, VAA/VAG, VONA (report from VO), VAR (Special AIREP, other ¹²)	FIR traffic capacity
	Flight Information Center (FIC)	Maintain communications links and ATS monitoring systems	Provide preflight and in-flight information about eruption	Provide preflight and in-flight information about volcanic cloud	SIGMET, NOTAM/ASHTAM, VAA/VAG, VONA (report from VO), Special AIREP	SIGMET, NOTAM/ASHTAM VAA/VAG, VONA (report from VO), Special AIREP
	International NOTAM Office (NOF)	Maintain communications links and ATS monitoring systems. Provide notice of pending hazard.	Provide notice of hazard	Provide notice of hazard	SIGMET, VONA (report from VO), Special AIREP	NOTAM/ASHTAM
Aerodrome		Maintain communications links and monitoring systems	Address ash contamination on runways, taxiways, ground equipment, planes	Address ash contamination on runways, taxiways, ground equipment, planes	Aerodrome Warning	Information for the NOTAM/ASHTAM
Operator	Airline Operations Center (AOC)	Maintain communications links and monitoring systems. Reroute aircraft around volcanoes identified in a pre-eruption state.	Reroute aircraft away from eruption.	Apply agreed SMS processes to adjust routes. Provide information to flight crew. Plan for reroute.	SIGMET, NOTAM/ASHTAM, VAA/VAG, VONA (report from VO), ash or SO2 report from flight crew, or ANSP (ATS, FIS, AIS).	Route/altitude selection, fuel, go/no-go decision, in-flight route/destination change.
	General Aviation Operators	Maintain communications links and monitoring systems	Appropriate decisions per SMS for operators of Large and Turbojet Aeroplanes.	Appropriate decisions per SMS for operators of Large and Turbojet Aeroplanes.	SIGMET, NOTAM/ASHTAM, VAR (Special AIREP), ash or SO2 report from ANSP (ATS, FIS, AIS)	Special AIREP, VAR

¹¹ In accordance with the *ATM Volcanic Ash Contingency Plan*

¹² Ash concentration forecast (if provided)

Current Services and Providers		Functions for:			Information	
		Pre-Eruption	Eruption ⁹	Volcanic Ash ¹⁰	Information Received and Used	Information Provided (shared)
Service Provider	Pilot / Flight crew (Commercial and General Aviation)	Maintain communications links and monitoring systems	Report eruption	Report volcanic ash, sulphur	SIGMET, NOTAM/ASHTAM, VAR (Special AIREP), ash or SO2 report from AOC or ANSP (ATS, FIS, AIS)	Special AIREP, VAR
	Original Equipment Manufacturers (OEM) or Type Certificate Holder (TCH)	Guidance and information to operators	Advice and information to operators	Advice and information to operators	Engineering and operations reports from operator.	Technical information about aircraft operation in volcanic ash, future/ongoing maintenance information requirements, details of inspection requirements

Table 1. Current service providers and their functions with respect to volcanic cloud information.

3.0 Description of Changes

Future services center on a number of changes that are intended to match the time frames of the Blocks of the ASBUs.

Module *B0-AMET* of the ASBUs is the baseline services for Block 0. The following is taken from ASBU module *B0-AMET*:

VAACs within the framework of the International Airways Volcano Watch (IAVW) respond to a notification that a volcano has erupted, or is expected to erupt or volcanic ash is reported in its area of responsibility. The VAACs monitor relevant satellite data to detect the existence and extent of volcanic ash in the atmosphere in the area concerned, and activate their volcanic ash numerical trajectory/dispersion model in order to forecast the movement of any ash cloud that has been detected or reported. In support, the VAACs also use surface-based observations and pilot reports to assist in the detection of volcanic ash. The VAACs issue advisory information (in plain language textual form and graphical form) concerning the extent and forecast movement of the volcanic ash cloud¹³, with fixed time validity T+0 to T+18 at 6-hour time-steps. The VAACs issue these forecasts at least every six hours until such time as the volcanic ash cloud is no longer identifiable from satellite data, no further reports of volcanic ash are received from the area, and no further eruptions of the volcano are reported. The VAACs maintain a 24-hour watch. Argentina, Australia, Canada, France, Japan, New Zealand, the United Kingdom and the United States are designated (by regional air navigation agreement) as the VAAC provider States. Accordingly, VAACs Buenos Aires, Darwin, Montreal, Toulouse,

¹³ There is no requirement in Annex 3 – *Meteorological Service for International Air Navigation* to monitor, observe and forecast volcanic gases.

Tokyo, Wellington, London, Anchorage and Washington make available the aforementioned advisories on the ICAO AFS.

This baseline describes the services as they are for the beginning of Block 0 with the timeframe of 2013. During Block 0, several improvements are proposed and they are described in subsequent sections of this roadmap.

Module *B1-AMET - Enhanced Operational Decisions through Integrated Meteorological Information* enables the identification of solutions when forecast or observed meteorological conditions impact aerodromes or airspace. Full ATM-MET integration is needed to ensure that: MET information is included in decision making process and the impact of the MET conditions (e.g., volcanic ash) are automatically taken into account. Module *B1-AMET* improves upon current operations where ATM decision makers manually determine the change in capacity associated with an observed or forecast MET condition (e.g., volcanic ash), manually compare the resultant capacity with the actual or projected demand for the airspace or aerodrome, and then manually devise ATM solutions when the demand exceeds the MET-constrained capacity value. Module *B1-AMET* also improves in-flight avoidance of hazardous MET conditions by providing more precise information on the location, extent, duration and severity of the hazard(s) affecting specific flights.

The aim of Module *B3-AMET - Enhanced Operational Decisions through Integrated Meteorological Information* is to enhance global ATM decision making in the face of hazardous MET conditions in the context of decisions that should have an immediate effect. Key points are a) tactical avoidance of hazardous MET conditions especially in the 0-20 minute timeframe; b) greater use of aircraft based capabilities to detect MET parameters (e.g. volcanic ash); and c) display of MET information to enhance situational awareness.

3.1 Changes intended through 2018:

Changes intended within the timeframe of 2013-2018 (i.e., Block 0 timeframe) to support Module *B0-AMET (Meteorological Information Supporting Enhanced Operational Efficiency and Safety)* are:

- Incorporate collaborative decisions and information sharing into volcanic ash cloud analyses and forecasts
- Increase the use of the aviation color-code alert system and provision of VONA by State VOs
- Develop confidence levels to aid decision makers as part of their safety risk assessment
- Improve ground-based, air-based and space-based observing networks to determine ESP and existing ash loading in the atmosphere
- Scientific research in support of reducing risks from volcanic ash hazards including understanding the impact of ash on aircraft and engines and the provision of enhanced guidance to operators

3.1.1 Collaborative decision analysis, forecasting and information sharing

The term Collaborative Decision Making (CDM) is a process used in ATM that allows all members of the ATM community, especially airspace users, to participate in the ATM decisions affecting all members. CDM means arriving at an acceptable solution that takes into account the needs of those involved. CDM for ATM is described in ICAO Document 9854 -*Global Air Traffic Management Operational Concept*, and Document 9982 – *Manual on Air Traffic Management System Requirements*.

A similar process has been proposed¹⁴ for volcanic ash and is called Collaborative Decision Analysis and Forecasting (CDAF). From a high level perspective and for an example, collaboration on the perimeter of the volcanic ash could be done, at a minimum, for events that affect high density traffic areas, or several FIRs and extend beyond the area of responsibility of one or more VAACs. This collaboration could be undertaken between predetermined partners, based on the event and extent. Table 2 lists some of the volcanic ash information needed by airspace users. As part of this process, information sharing between the partners is essential, so that all possible outcomes can be considered. Table 3 lists the partners for collaboration and information sharing as well as the expected role of the partners. The final decision (i.e., the location of horizontal/vertical airspace volcanic ash contamination boundaries) will depend on agreed upon guidelines that may vary depending on the size and scope of the volcanic event, but efforts should be made to ensure that the authority for the final decision concerning volcanic ash information resides with the designated Primary VAAC, otherwise the final output (e.g., forecast) may lead to inconsistency and hamper effective decision making by ATM and airlines. Once the decision is finalized it can be integrated into ATM decision tools for a CDM process by ATM decision makers and airspace users.

One of the challenges for the IAVWOPSG is to establish agreed procedures to support CDAF which have not been defined.

Need to know	Information Sharing	Output from a Collaborative Decision
Location of volcanic ash contamination boundaries.	Share data from ground, air, and space observing platforms	Current horizontal and vertical extent (perimeter) of volcanic ash contamination to be used in decision support systems and forecast products.
How the volcanic ash boundaries are changing and where will they be in the future.	Share various outputs of dispersion models	Forecast horizontal and vertical extent of the volcanic ash contamination and produce seamless products
If provided and available, multiple contours of ash contamination	Share various outputs of dispersion models	Forecast horizontal and vertical extent of multiple contours of ash contamination

Table 2. Collaborative decisions for volcanic ash cloud information

¹⁴ IVATF Recommendation 4/18, IAVWOPSG Conclusion 7/21 refers.

Partners	Role
Primary VAAC	Produces preliminary forecast and shares with rest of partners. Considers input and suggested changes from participating partners. Has the final decision on the forecast after considering information and input from partners.
Other VAAC(s)	Shares new information with participating partners. Reviews preliminary forecast and provides suggested changes.
VO(s)	
MWO(s)	
State’s NMHS	
University or Research Centers (dispersion modeling)	
Others (TBD), e.g., operators	Share information.

Table 3. Partners for the collaboration and information sharing and expected roles

3.1.2 Increase the use of the aviation color-code alert system and provision of VONA by State VOs

Not all State VOs issue a VONA, which provides a concise statement describing the activity at the volcano, as well as the specific time of the onset and duration of the eruptive activity. VONAs also contain a color code (see 2.1.1). As a form of “best practice”, this roadmap recommends that all State VOs use the VONA and its aviation color-code alert system for the provision of volcano information.

3.1.3 Develop confidence levels to aid decision makers as part of their safety risk assessment

In February 2012, the IATA met with the VAACs and discussed their need for levels of confidence in the volcanic analyses and forecasts (i.e., VAA/VAG). These confidence levels would be used or translated into the risk assessment conducted by operators to best determine the aircraft flight route or track.

The VAAC practices for presentation of ‘confidence’ must be consistent and be a well understood process to ensure a harmonized regional interoperability within the operator’s risk assessment process. Development of guidance material should be conducted in parallel with the development of the presentation of confidence.

Development of confidence levels are considered to be a key factor in improving the quality of information provided which will aid in the decision making process as part of an operators safety risk management plan.

3.1.4 Improve ground-based, air-based and space-based observing networks to determine ESP

Observation and forecasts information on volcanic ash will require continued improvement of observational capabilities globally, including volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and airborne sampling.

3.1.5 Scientific research in support of reducing risks from volcanic ash hazards including understanding the impact of ash on aircraft and engines and the provision of enhanced guidance to operators

Scientific research in support of reducing risks from volcanic ash hazards should aim for tangible improvements in the detection and measurement of volcanic plumes and ash clouds during eruptions and in the accuracy of model forecasts of ash transport and dispersion. Research topics (both new and on-going) pertinent to these goals include the following:

- Characterizing volcanic plumes at/near the source
- Understand the evolution of volcanic ash and gas clouds in time and space
- Verification of the model forecasts

In addition,

- Develop an understanding of the impact of ash on aircraft and engines and provide enhanced guidance to operators
- Scientific research to support service delivery for volcanic ash hazard risk reduction

Since 2010 manufacturers have continued work on developing their understanding of the impact of volcanic ash. This will continue through a number of initiatives including involvement of the major manufacturers in the National Aeronautics and Space Administration (NASA) and United States Air Force (USAF) Vehicle Integrated Propulsion Research (VIPRIII) test programme and coordination between manufacturers through the International Coordinating Council of Aerospace Industries Associations (ICCAIA) Volcanic Ash working group. As this knowledge and understanding increases enhanced guidance to operators will be provided where possible.

Further description and discussion regarding research is detailed in Working Paper 14 from the fourth meeting of the IVATF.

3.2 Changes intended within 2018-2023:

Changes intended within the timeframe of 2018-2023 (i.e., Block 1 timeframe) to support Module B1-AMET (*Enhanced Operational Decisions through Integrated Meteorological Information*) are:

- Enhance the provision of SIGMETs in support of operational decisions
- Transition to all digital format for all volcanic ash information

- Further develop ATM for operations in or close to areas of volcanic ash
- Increase the VAA/VAG issuance frequency and time steps
- Provide additional information which reflects the forecast of volcanic ash beyond 18 hours
- Continued improvement in ground-based, air-based and space-based observing networks to determine ESP
- Continued scientific research in support of reducing risks from volcanic ash hazards

3.2.1 Enhance the provision of SIGMETs in support of operational decisions

A large volcanic ash cloud over congested, multi-States areas such as Europe could result in multiple SIGMET information messages, all being in effect at the same time. Each of these SIGMETs becomes a part of a jigsaw puzzle for the user to assimilate, in order to obtain a good understanding of the entire area of the volcanic cloud. As a result the International Air Transport Association (IATA) has stated that they have strong preference for the VAA vs. the SIGMET, i.e., that is one message covering a large region.

Since SIGMETs are, in most cases, based on the first portion of a VAA, that portion of the VAA/VAG could technically be elevated in status to serve as a SIGMET. Making the VAA/VAG's first six-hour portion (i.e., T+0 and T+6 hour) equivalent to the SIGMET would reduce the information overload experienced by users (pilots, operators, etc) who must currently track dozens of SIGMETs for their particular flight in congested areas.

Under today's operations each MWO is responsible for the provision of a SIGMET for their FIR in support of defining the location and forecast position of the ash cloud. However, many MWOs do not have the skill to provide this service and are dependent on the VAAC for this information via the VAA. Some MWOs have more advanced skill levels to provide value input. In those cases the MWO should coordinate with the VAAC and advise the VAAC that the information provided in the VAA is not necessarily reflective of conditions in their FIR. With the proposal to support CDAF this divergence of information should be minimized where the information provided in the VAA is consistent with the SIGMET or vice versa. If achievable this then begs the issue on whether there is a need to retain both products but rather provide a single high quality product to the operator and ANSP in support of integration of MET information into air traffic flow management (ATFM) systems for the routing of aircraft away from a hazard.

Proposed SIGMET enhancements are:

- The first six-hour portion of the VAA (i.e., T+0 and T+6 hour) is equivalent to the SIGMET for a volcanic ash cloud (with validity for one or more FIRs)
- MWOs should participate in the CDAF process and share information with the VAAC to ensure the VAA reflects the conditions in their FIR

- SIGMET *Information* messages should only be issued by a MWO for those cases where the VAA is not yet available or the VAA does not reflect the conditions in the FIR even after the CDAF process.

It is noted that IATA has formulated a set of requirements which were presented to the VAAC Best Practices Seminar of 12-13 June 2012 and expanded upon at IAVWOPSG/7. Those requirements will be considered in this enhancement process taking into account the issues of sovereignty, cost recovery and collaborating procedures among related States.

3.2.2 Transition to all-digital format for all volcanic ash information

Today's volcanic cloud products are primarily text-based (e.g., SIGMET information message), with some supplementation of graphic-based products (e.g., VAG). Future volcanic cloud information must be provided in a digital format in order to better serve aviation users and decision makers. The visualization of volcanic information must be capable of being displayed on moving maps, cockpit displays, radar screens, etc.

The IAVWOPSG, recognizing the need for digital information, formulated Decision 7/25 which calls for the development of a digital format of the VAA/VAG in an XML/GML format for implementation with Amendment 77 to Annex 3 – *Meteorological Service for International Air Navigation*.

The transition from text and graphic-based products to all-digital formats will take time, as there will continue to be a need for legacy text-based products for several years, especially in certain regions of the world.

3.2.3 Further develop ATM for operations in or close to areas of volcanic ash

In an effort to increase information exchange between ATM and operators, make available to affected ANSP's the outcomes of the operators risk assessment for their consideration, especially where applicable to ATFM.

3.2.4 Increase VAA/VAG issuance frequency and time steps

Operators need frequent updates of volcanic ash information especially in congested airspace and around constrained airports. The current VAA/VAG with its 6-hourly issuance and 6-hour time steps does not meet those needs.

The VAA/VAG presenting levels of certainty should be developed to include three hourly time-step information. There is a need to have the capability to increase the frequency of VAA/VAG for pre-defined operational conditions. This would be when ash is present in congested airspace and around capacity constrained airports.

3.2.5 Provide additional information which reflects the forecast of volcanic ash beyond 18 hours

Operators at IAVWOPSG/7 expressed an interest in having volcanic ash information beyond the current practice of T+18 hours for long-haul flight planning and management of airline operations. While it is understood that today's numerical models provide information for various meteorological elements out to several days, providing volcanic ash information beyond T+18 hours introduces a number of uncertainties into the forecast as a result of unknown or uncertain source terms and meteorology as well as inaccuracies in the physics of the dispersion/transport models. With this understanding, the goal is to provide additional information which can realistically reflect the forecast of volcanic ash beyond 18 hours.

3.2.6 Continued improvements in ground-based, air-based and space-based observing networks to determine ESP

Improvements to volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and airborne sampling will continue in Block 1, building on the accomplishments from Block 0.

3.2.7 Continued scientific research in support of reducing risks from volcanic ash hazards

Scientific research in support of reducing risks from volcanic ash hazards will need to continue in Block 1 and build upon the area and topics listed in section 3.1.5.

3.3 Changes intended within the time frame of 2023-2028

Changes intended within the time frame of 2023-2028 (i.e., Block 2 timeframe), which is an extension of ASBU Block 1, to support Module B1-AMET (*Enhanced Operational Decisions through Integrated Meteorological Information*) are:

- Develop volcanic ash nowcasts
- Develop volcanic ash forecasts that include the use of probability

3.3.1 Develop volcanic ash nowcasts

Users need to know the current location of the volcanic ash. The VAA/VAG and SIGMET provide information about the ash at T+0, but these products are issued every six hours, thus at two hours after T+0, users must do some kind of interpolation between T+0 and T+6 to obtain an estimate of where the ash contamination boundary lies. Providing VAA/VAG at three hour time-steps will help this issue, but more can be done with the transition to a digital information data base for meteorological information, as part of the ASBUs, including volcanic ash.

In the Block 2 timeframe, it is foreseen that a three-dimensional representation of the current or near-current volcanic ash contamination boundaries, known in this document as a "nowcast", could be made available and extracted by the user. Nowcasts would be updated at a

high frequency and provide a more realistic assessment of the location and extent of the ash cloud.

3.3.2 Develop probabilistic volcanic ash forecasts

Current volcanic ash forecasts, such as the VAA/VAG, are deterministic forecasts. They are a yes/no forecast, with respect to the depiction of the airspace impacted by volcanic ash contamination. These forecasts are based on the definition of “discernible ash” as a fundamental criterion.

Volcanic ash transport and dispersion models can produce an array of solutions (e.g., forecasts) by varying the model input. Changes in meteorological parameters and ESP will result in different forecast outputs that affect the 4-dimensional shape (3-dimensional shape and change of shape with time) of the cloud. The purpose of a probabilistic forecast is to provide decision makers with an assessment of all the likelihoods of a weather parameter’s risk of occurrence exceeding a defined magnitude. Probabilistic forecasts help multiple decision makers use the same weather information, applying their own operational constraints to determine risk to their operation. Section 5.2 identifies those functions that could be provided in deterministic and probabilistic terms.

From a high-level perspective, probability forecasts may be based on an ensemble approach. An ensemble is one way to account for some degree of uncertainty. For instance, the model can be run many times, each time with a realistic variant of one of the uncertain parameters (e.g. ash amount, ash column height, eruption start time and duration, input meteorology dataset, with and without wet deposition, etc.). Taken as a whole, the variability of the ensemble members’ output gives an indication of the uncertainty associated with that particular ash forecast.

The application of probabilistic forecasts will best benefit high-density (congested) traffic areas, where decision makers can benefit from more than just a deterministic forecast. Also, decision support systems can use the probabilistic information to provide route and altitude selections based on user’s acceptance thresholds.

For operators to effectively use ‘probabilities’ for specific time and space within the initial and ongoing risk assessments, a thorough understanding of the output from the VAAC is needed by operators and flight crew.

3.4 Changes intended by 2028 and beyond

Changes intended by 2028 (i.e., Block 3 timeframe) in support of Module B3-AMET (*Enhanced Operational Decisions through Integrated Meteorological Information*) are:

- Develop other volcanic derived contaminant forecasts, specifically SO₂
- Integrate volcanic ash forecasts into decision support systems for trajectory based operations

- Develop understanding of the impact of ash on aircraft and engines and provide enhanced guidance to operators
- Incorporate processes and procedures for the use of airborne detection equipment

3.4.1 Develop other volcanic derived contaminant forecasts, specifically sulphur dioxide

While the document has focused on volcanic ash there is strong evidence that there is a need to expand the services to other toxic elements that are typically associated with volcanic eruptions.

During volcanic eruptions, a number of toxic gases may be emitted in addition to ash; these include SO₂, hydrogen fluoride, and hydrogen sulphide amongst many others. Each of these gases has different atmospheric dispersion properties, and so gas clouds may be found coincident or separate from ash clouds. Of these gases, SO₂ is of particular importance as it may be emitted in large quantities and potentially has significant health effects. The documented experience to date of in-flight encounters with sulphurous gases suggests that SO₂ has never been a significant immediate safety hazard to an aircraft or health hazard to its occupants.

Through the work of the IVATF and IAVWOPSG¹⁵, it was determined that ICAO, through an appropriate expert group or groups, should determine a clear meteorological/atmospheric chemistry requirement (such as a critical level of SO₂ in the atmosphere that would be observed or forecast) that, after passing through the aircraft's ventilation system, could pose a health risk to the aircraft's occupants.

3.4.2 Integrate volcanic ash forecasts into decision support systems for trajectory based operations

One of the key elements in Module B3-AMET of the ASBUs is the integration of meteorological information into decision support systems. Future ATM decision support systems need to directly incorporate volcanic ash nowcasts and forecasts, allowing decision makers to determine the best response to the potential operational effects and minimize the level of traffic restrictions. This integration of volcanic ash nowcasts and forecasts, combined with the use of probabilistic forecasts to address uncertainty, reduces the effects of volcanic ash on air traffic operations.

3.4.3 Development of index levels for ash tolerances

Different aircraft and engine designs may be affected differently by volcanic ash. For example, modern turbofan engines ingest large volumes of air and their turbines run hotter than the melting point for volcanic ash constituents. They typically utilize exotic turbine component coatings that can be affected by volcanic aerosols such as sulfates and chlorides. They also use turbine nozzle cooling and blade cooling with passages that are vulnerable to ash blockage. Older turboprop or turbofan engines typically do not have these same features and have

¹⁵ IAVWOPSG Conclusion 7/34 and Decision 7/35 refers.

different vulnerabilities. These design and operational differences can significantly affect the engine's susceptibility to volcanic ash.

In the longer term the development of a volcanic ash index for ash tolerances of various types of engine/aircraft combinations may allow operators and ATM to take advantage of quantitative volcanic ash forecasts. It should be recognized that this may not be feasible due to the extensive testing and evaluation required to adequately cover the range of aircraft and engines in service.

3.4.4 Develop processes associated with airborne detection equipment

To allow operators to take advantage of tactical on-board volcanic ash detection equipment, ATM processes and procedures will need to be developed and incorporated into ATM Contingency Plans.

4.0 Proposed Roadmap

The proposed way forward will involve all the changes described in Section 3 above. Specifically:

Through 2018:

- Incorporate collaborative decisions and information sharing into volcanic ash cloud analyses and forecasts
- Increase the use of the aviation color-code alert system and provision of VONA by State VOs
- Develop confidence levels to aid decision makers as part of their safety risk assessment
- Improve ground-based, air-based and space-based observing networks to determine ESP
- Scientific research in support of reducing risks from volcanic ash hazards including understanding the impact of ash on aircraft and engines and the provision of enhanced guidance to operators

2018-2023:

- Enhance the provision of SIGMETs in support of operational decisions
- Transition to all digital format for all volcanic ash information
- Further development of ATM for operations in or close to areas of volcanic ash
- Increase the VAA/VAG issuance frequency and time steps
- Provide additional information which reflects the forecast of volcanic ash beyond 18 hours
- Continued improvements in ground-based, air-based and space-based observing networks to determine ESP
- Continued scientific research in support of reducing risks from volcanic ash hazards

2023-2028:

- Develop volcanic ash forecasts that include the use of probability
- Develop volcanic ash nowcasts

2028 and beyond:

- Develop other volcanic derived contaminant forecasts, specifically SO₂
- Integrate volcanic ash forecasts into decision support systems for trajectory based operations
- Development of index levels for ash tolerances
- Incorporate processes and procedures for the use of airborne detection equipment

4.1 Assumptions and Constraints

The proposed concept is based on the following assumptions:

- IAVW retains global legal mandate for volcanic ash service delivery
- The first six-hour forecast from the VAA (i.e., T+0 and T+6 hour) can be used equivalent to a SIGMET
- Probabilistic forecasts can be utilized by aviation decision makers
- Probabilistic forecasts are best suited for users in congested airspace, but can also be beneficial for users in uncongested airspace
- Before a probability can be derived from an ensemble, there is a need to “calibrate” the ensemble, as the number of elements in a “cluster” is not necessarily a reliable measure of probability if the variations of the initial states and ESP’s are not driven by a scientifically sound selection principle
- Index levels for volcanic ash tolerances can be developed
- Continuing user demand for phenomena based information rather than FIR based information

The following constraints may impede the implementation of the proposed concept:

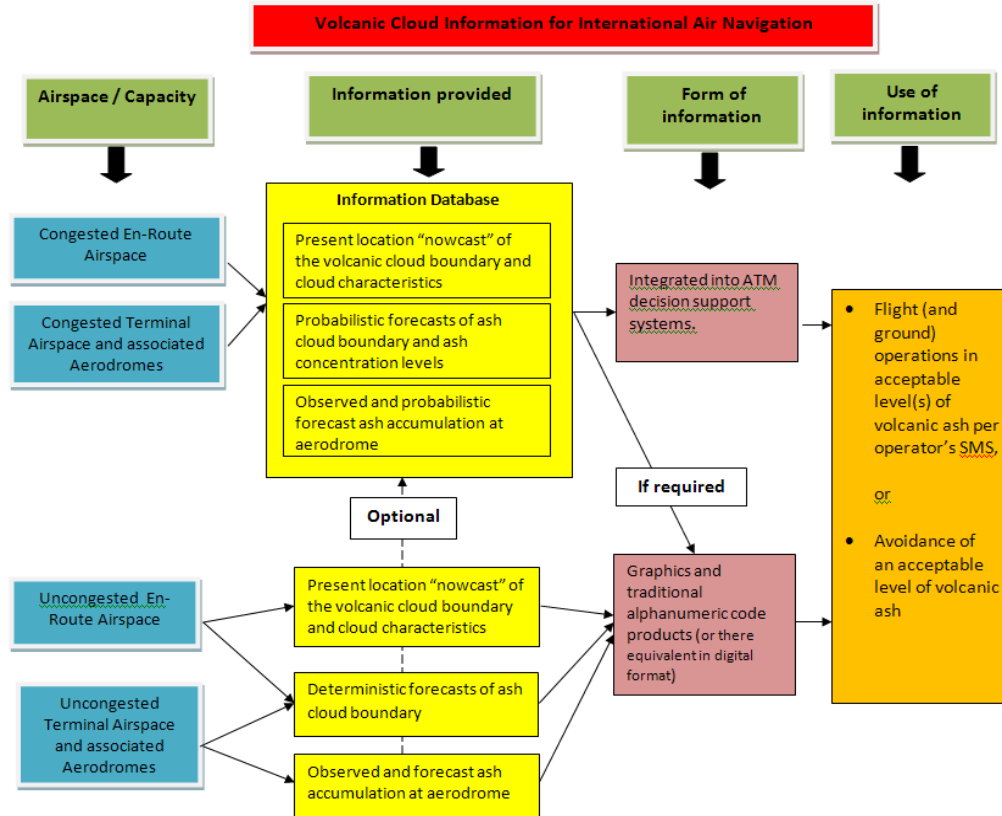
- The development of certifiable volcanic ash tolerances may take many years, or may not be feasible or beneficial to operators (if by 2028 the development is not possible then further work will be done to improve the avoidance of ash)
- Some States may not accept the VAA as equivalent to the SIGMET due to legal and political issues

4.2 Operational Environment

By 2028, volcanic cloud information will reside on a common information sharing platform and be part of the System Wide Information Management (SWIM) concept in support of global ATM.

4.3 Operations

Operations during a volcanic event depend on the information available as well as a function of



classification of airspace that being high density (congested) airspace versus low density (uncongested) airspace.

Nowcasts and deterministic forecasts may adequately serve the users of airspace that is not congested, and offers ample options for volcanic ash avoidance without great fuel penalties for the operator. But for congested airspace, the provision and use of probabilistic forecasts of the volcanic ash could be beneficial in order to achieve maximum efficiency of the air traffic system.

Figure 3 provides a high level schematic of meteorological service per airspace capacity. It should be noted that the provision and use of probabilistic forecasts is not restricted or limited to congested airspace, rather the "optional" block in Figure 3 denotes that operators in uncongested airspace, e.g., oceanic User Preferred Routes (UPR), can take full advantage of these forecasts.

Figure 3. Operations concept using volcanic cloud information per airspace capacity. Note that the "optional" box indicates that the Information Database and its probabilistic forecasts are available for users of uncongested airspace.

4.4 Supporting Infrastructure

In Blocks 0 through 2, the information on volcanic ash will continue to be product centric and be produced by humans in traditional alphanumeric text along with a graphical image. Production of these products will inevitably migrate from the MWOs to the VAACs.

In the Block 3, all relevant information on the volcanic clouds will reside on a common information sharing platform.

4.5 Benefits to be realized

The proposals for volcanic cloud information to be developed and implemented as noted in sections 3.1, 3.2, and 3.3 will provide users with volcanic ash information that has greater confidence and usability. Moving from a product centric environment to an information centric environment will meet the future operational needs of aviation decision-makers. Also, decision support systems can use the probabilistic information to provide route and altitude selections based on user's acceptance thresholds. The integration of volcanic cloud forecasts, combined with the use of probabilistic forecasts to address uncertainty, will lead to more effective and informed decision making and planning for air traffic operations. Finally, if feasible, the development of a volcanic ash index for ash tolerances for various types of engine/aircraft combinations may allow operators and ATM to take advantage of volcanic ash concentration forecasts.

5.0 Needs and Goals

5.1 Operational Needs

The following is a set of high-level operational needs¹⁶ of aviation users for trajectory based operations in support of international air navigation:

- Determine the onset of a volcanic event (i.e., eruption)
- Determine if an eruption and any associated volcanic ash are a hazard to international air navigation based on any agreed threshold values of mass concentration
- Determine what aerodromes and airspace are affected by the eruption and associated cloud
- Determine when the eruption has ended
- Determine when the volcanic ash has dispersed below agreed threshold values
- Determine when the aerodrome/airspace affected by the eruption and/or cloud is safe to operate in or through
- Determine the cost of the event and stakeholder satisfaction

¹⁶ As determined by the author based on information from users at ICAO's IVATF.

5.2 Functional Goals

Table 4 lists a set of functional goals for volcano eruption and volcanic cloud information based on different types of airspace and aerodrome densities (i.e., capacity or congestion). An “X” in the table’s cell indicates that this function is needed for this airspace and aerodrome. A “P” or “D” indicates whether the forecast function is Probabilistic or Deterministic. A “D, P” indicates that both are provided.

Future Functional Goals for Volcano Eruption and Volcanic Cloud Information						
	Route operations		Terminal control area (TMA) operations		Aerodrome	
	Congested (high density)	Un-congested (low density)	Congested (high density)	Un-congested (low density)	High density	Low density
Volcano Eruption						
Detect an Eruption in all kinds of meteorological and day/night conditions (i.e., including tropical regions where convective activity is common)	X	X	X	X	X	X
Determine the height of the eruption plume	X	X	X	X	X	X
Determine the duration of the eruption	X	X	X	X	X	X
Detect, determine and report the heightened volcanic activity (pre-eruption)	X	X	X	X		
Volcanic Cloud						
Determine the perimeter, top and base of the volcanic cloud in all kinds of meteorological and day/night conditions	X	X	X	X		
Determine when the "volcanic cloud" is a hazard due to:	Ash	X	X	X	X	X
	SO2	X	X	X	X	X
	Electro-magnetic risks to avionics	X	X	X	X	X
	Other (TBD)					
Determine the perimeter of the lowest acceptable ash contamination level (ash cloud)	X	X	X	X	X	X
Determine the perimeter of the gaseous cloud	X	X	X	X	X	X
Determine the eruption source parameters	X	X	X	X	X	X
Forecast the perimeter of the lowest acceptable ash contamination level (ash cloud)	D, P	D, P	D, P	D	P	D
Forecast the top and base height of the lowest acceptable ash contamination level (ash cloud)	D, P	D, P	D, P	D	P	D
Forecast the movement of the lowest acceptable ash contamination level	D	D	D	D		

Future Functional Goals for Volcano Eruption and Volcanic Cloud Information						
	Route operations		Terminal control area (TMA) operations		Aerodrome	
	Congested (high density)	Un-congested (low density)	Congested (high density)	Un-congested (low density)	High density	Low density
Forecast the growth and decay of the lowest acceptable ash contamination level (ash cloud)	D, P	D, P	D, P	D		
Forecast the location of the gaseous cloud	D, P	D, P	D, P	D	P	D
Forecast the top and base height of the gaseous cloud	D, P	D, P	D, P	D	P	D
Forecast the movement of the gaseous cloud	D, P	D, P	D, P	D		
Forecast the growth and decay of the gaseous cloud	P	D, P	P	D		
Determine when the volcanic cloud is no longer a hazard	X	X	X	X		
Determine when the volcanic cloud is hidden or mixed with clouds, especially cumulonimbus clouds and cirrus clouds	X	X	X	X		
Forecast when the volcanic cloud is hidden or mixed with meteorological clouds	P	D, P	P	D		
Volcanic Ash Accumulation						
Determine the ash accumulation at the aerodrome					X	X
Forecast the ash accumulation at the aerodrome					D, P	D

Table 4. Future functional goals for volcano eruption and volcanic cloud information

6.0 Operational Scenarios

Two kinds of operational scenarios are envisioned, avoidance of the volcanic cloud, and planned flight into a cloud. The information for both scenarios is in the form of nowcasts and forecasts that are integrated into decision support systems.

Nowcasts

The three-dimensional representation of the current or near-current volcanic ash cloud, including depiction of the perimeter of the lowest acceptable level of ash contamination, in a common exchange format that provides integration into decision making tools as well as offers a graphical depiction of the information. In the avoidance scenario, the nowcast provides users

with the location of discernible volcanic ash. As the volcanic ash moves or changes, the nowcast is updated at a temporal frequency that meets user needs and service provider capabilities. For flight into acceptable levels of ash, volcano ESP, *in situ* measurements of the airborne volcanic ash (from ground-based, space-based, or airborne-based observing platforms) are required to provide a nowcast that has a high level of confidence of the ash concentration levels inside the cloud.

Forecasts

The four-dimensional representation of volcanic ash, including depiction of the perimeter of the lowest acceptable level of ash contamination, ash concentration levels and indices, in both deterministic and probabilistic terms, in a common exchange format that provides integration into decision making tools as well as offers a graphical depiction of the information. For both scenarios, the forecasts would be valid “X” hours and up to “Y” days, but would contain finer temporal resolution in the near time frame. Forecasts would also be provided in terms of uncertainty (use of probability). For flight into acceptable levels of ash contamination, volcano ESP, quantitative measurements of the airborne volcanic ash (from ground-based, space-based or airborne-based observing platforms), would be needed to enable accurate validation of ash contamination to support airline decision making.

The Collaboration Process

Aligned with the above forecast process is the collaborative decision and information sharing process. In this scenario, collaboration on the nowcasts and forecasts will occur on a regular basis such that all users are afforded the opportunity to contribute information. Information will be shared and could be made available on an information database or web portal that is jointly run by the VAACs.

Civil aviation operators will then apply these new nowcasts and forecasts to their operations specifications per their Safety Management System (SMS) and any specific Safety Risk Assessments (SRA) for any operations other in areas of a volcanic ash cloud.

APPENDIX D

STRATEGY FOR THE FUTURE PROVISION OF INFORMATION ON HAZARDOUS METEOROLOGICAL CONDITIONS

Overall Objective

To develop a high-level strategic statement relating to the provision of information on hazardous meteorological conditions for international civil aviation, covering the period 2014 to 2025.

This strategic statement is expected to support recommended actions concerning aeronautical meteorological service provision arising from ICAO's 12th Air Navigation Conference (AN-Conf/12 held 19 to 30 November 2012), while recognizing that there is a need for shorter term action in some areas to rectify existing deficiencies in the provision of information on hazardous meteorological conditions to international civil aviation.

This strategic statement is intended to support and align with the programme and timing of the aviation system block upgrades (ASBUs)¹⁷ methodology contained in the Fourth Edition (2013) of ICAO's Global Air Navigation Plan (GANP) (Doc 9750-AN/963). The ASBUs provide target availability timelines for a series of operational improvements – technological and procedural – that will eventually realize a fully-harmonized global air navigation system.

Refer: Agreed Action 5/1, Meteorological Warnings Study Group (METWSG), 5th Meeting, Montréal, 20 to 21 June 2013.

Problem Definition

There is a significant and long standing issue regarding deficiencies in some ICAO Regions concerning the provision of SIGMET information and harmonization of such information within the current State meteorological watch office (MWO) flight information region (FIR)-based system¹⁸.

Deficiencies in SIGMET provision is a major concern, particularly given the programmed migration to performance-based air traffic management principles set out in the GANP. The need to provide better meteorological support for the safety and efficiency of international civil aviation is particularly important.

IATA and its member airlines continue to express concern over the safety and efficiency of operations in areas where SIGMETs are rarely, if ever, issued by MWOs.

Some States have a chronic lack of capacity¹⁹ to fully meet their Annex 3 – *Meteorological Service for International Air Navigation* responsibilities. In particular, some smaller developing States have difficulty with SIGMET provision. Some developed States also have significant problems in this area²⁰. These

¹⁷ Refer Working document for the Aviation System Block Upgrades, 28 March 2013.

¹⁸ Where a State has accepted the responsibility of providing air traffic services within an FIR (or control area), SIGMET information is to be issued by an MWO concerning the occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations. Such phenomena include severe turbulence, severe icing and others.

¹⁹ Capacity includes people, expertise and underpinning infrastructure.

²⁰ The acute lack of capacity of some States to meet many Annex 3 responsibilities regarding SIGMET issuance was emphasised during a SIGMET trial conducted by the METWSG in April to July 2011. This trial was aimed at testing the feasibility of regional SIGMET advisory centres (RSAC) assisting MWOs to issue SIGMETs by providing them with SIGMET advisory information.

difficulties result in particular MWOs not being able to issue SIGMETs in a timely, reliable, or accurate manner.

The problem is not unique to any one State or any one ICAO Region. The issues range from State non-compliance in actually issuing SIGMET, non-functional or non-supportive MWO, through to providing SIGMET in incorrect formats. The problem is compounded with the current FIR-based system of SIGMET provision also presenting co-ordination challenges, particularly over areas with small and irregular FIR boundaries, as well as in those ICAO Regions with many small FIRs.

Furthermore, IATA has noted that inconsistent cessation or change of hazardous meteorological conditions information at FIR boundaries, due to differences in methods and working practices between MWOs, creates significant and expensive flight management issues.

Any remedial developments must therefore align meteorological inputs to the evolving technical capacity of modern airline and aircraft operations and the increasing globalization of the civil aviation industry.

Statement of Strategic Intent

Reflecting its strategic objectives, and in an increasingly competitive business and technically advancing environment, ICAO recognizes:

- (a) the increasing demand from international civil aviation users for efficient and effective phenomena-based hazardous meteorological condition information, seamlessly covering the globe in a co-ordinated and harmonized way; and
- (b) the limitations, inconsistencies and gaps in the current production of hazardous meteorological conditions information (in the form of SIGMET) required to be produced by each MWO for its associated FIR.

To meet international civil aviation user demands, and make best use of resources (including technology), this strategy proposes to transfer the issue of defined²¹ regional hazardous meteorological condition information to appropriately resourced regional centres, supported by respective meteorological watch offices (MWOs) as may be determined, in a three phased approach and in support of the Aviation System Block Upgrades (ASBUs) methodology of ICAO's Global Air Navigation Plan (GANP), as follows:

1.1 **Phase One (2014-2017):** The first phase is the establishment of regional hazardous weather advisory centres (RHWACs) to assist MWOs with the existing provision of SIGMET information in those ICAO Regions in need of such support.

Explanatory note: Formal planning and development will begin with a mandate from the ICAO Meteorology Divisional Meeting in July 2014. All planning and arrangements will be in place with formal ratification of the scheme expected in Amendment 77 to Annex 3 (with intended applicability in November 2016), and parallel documentation in Regional Air Navigation Plans. The allocated RHWACs will commence operations at a date to be agreed but no later than December 2017.

1.2 **Phase Two (2016-2020):** The second phase (including the transition of the RHWACs) will cover the centralization of SIGMET-related responsibilities of MWOs to regional hazardous weather centres (RHWCs) supporting multiple FIRs. This may include the amalgamation of existing volcanic ash advisory

²¹ Part of the first phase would be the identification of exactly what constitutes hazardous meteorological conditions, excluding the contemporary work of VAACs, TCACs and pending the expected future work of space weather centres.

centres (VAACs) and tropical cyclone advisory centres (TCACs)²² into these RHWCs, and will include close liaison with users and detailed definition of all products to be supplied by the new centres.

Explanatory note: Formal planning and development will begin in 2016 with the completion of planning for Phase 1. All planning and arrangements will be in place with formal ratification of the scheme expected in Amendment 78 to Annex 3 (with intended applicability in November 2019), and parallel documentation in Regional Air Navigation Plans. Planning will include the development of suitable RHCW performance metrics to support Phase 3. The allocated RHWCs will commence operations at a date to be agreed but no later than December 2020.

1.3 **Phase Three (2020-2024):** This phase primarily covers the review of the performance of the regional hazardous weather centres, making any appropriate recommendations in this regard. The review will also include, inter alia, an evaluation of the efficacy, or otherwise²³, of consolidating, in a further phase (potentially a Phase Four), hazardous meteorological condition information issued from a few centres conjointly covering the globe²⁴, in or after 2025.

Explanatory note: The review will be undertaken in 2023 using performance data compiled for the years 2020 – 2022 inclusive. The review will include evaluation of operations, modelling, logistics, communications and science capability. A final report and recommendations will be provided by the end of 2023. If recommended, a reduced number of regional centres, or a few centres conjointly covering the globe, could be operating in 2025 if mandated in Amendment 80 to Annex 3 (with intended applicability in November 2025). It is noted, however, that any highly significant recommendations from this review process may need to go an ICAO Meteorology Divisional meeting around 2025/2026 for ratification, delaying implementation of any significant changes until after about 2026.

1.4 **Note**

Notwithstanding the strategic approach outlined above, and in accordance with Annex 3, Chapter 2, States can enter into bilateral arrangements at any time to obtain the support they may need to fulfil their MWO obligations with regard to SIGMET provision. As an interim arrangement, while Phase One of the strategy is implemented, such action is encouraged.

Supporting Considerations

This section references the areas of consideration taken into account in the derivation of the statement of strategic intent for the future provision of information on hazardous meteorological conditions.

1.5 **ICAO Strategic Objectives**

ICAO has established three strategic objectives for years 2011, 2012 and 2013:

- (a) Safety: Enhance global civil aviation safety.
- (b) Security: Enhance global civil aviation security.
- (c) Environmental Protection and Sustainable Development of Air Transport: Foster harmonized and economically viable development of international civil aviation that does not unduly harm the environment.

In years 2014, 2015 and 2016 the number of strategic objectives of ICAO will increase to five. Ten key air navigation policy principles²⁵ are contained in the GANP, intended to guide global, regional and State air navigation planning consistent with ICAO's strategic objectives.

1.6 **General Considerations**

²² VAACs and TCACs have been operating successfully in a regional capacity for the past several decades.

²³ It is accepted that the review may recommend slowing, delay, or postponement of further consolidation.

²⁴ There is a high level expectation of IATA for a better global hazardous weather scheme than exists today, consisting of only a few regional centres conjointly covering the globe, to be fully assessed and implemented in the mid-term.

²⁵ Refer Doc 9750-AN/963 — 2013-2028 Global Air Navigation Plan.

Those aspects contributing to the derivation of this document, not covered elsewhere, are:

- (a) Identification of hazardous meteorological conditions best managed in a consolidated manner;
- (b) Utilization of information within the envisaged data-centric environment²⁶ as part of the system wide information management (SWIM) concepts.
- (c) Need for evaluation of cost recovery schemes to support regional centres.
- (d) Need for evaluation of relevant airspace sovereignty, liability, and obligations of States - noting the range of political perceptions of regional and global change.
- (e) Need to ensure robust implementation of quality management system (QMS) and safety management system (SMS) principles and requirements in any new system.

1.7 Discussion

Article 28 of the ICAO Convention on International Civil Aviation (Doc 7300) and Annex 3 to that Convention defines meteorological services in support of international air navigation. Over the past six decades, amendments of Annex 3 have been largely centred on meteorological observations and forecasts rather than the nature of the underlying global systems structures.

In the 1980s the international community recognized technological advances and user demand changes (for example, increasing long-haul flights) with the establishment of the world area forecast system (WAFS). The WAFS initially provided global wind and temperature data with planning for significant weather forecasts (as currently provided). In the final phase of WAFS implementation, the WAFS replaced regional area forecast centres (RAFC) which had provided regional forecasts within their defined area of responsibility, operating within the limits of technology and communication networks of the times. The development of the WAFS hinged on global modelling capabilities, the advent of satellite remote sensing techniques, and satellite broadcast of WAFS products to States/users across the globe.

Other changes reflected this on-going development of international civil aviation. An example is the removal of the two-hour rule that restricted dissemination of METAR/TAF reports within a two-hour flying distance from the aerodrome. Just as it was recognized that this two-hour rule was obsolete then, the international civil aviation community recognizes now that future systems and the nature of meteorological information will need to meet new and different requirements within new and different contexts.

Reflecting this perspective, the future vision for aeronautical meteorological service practices was covered at the AN-Conf/12.

The international civil aviation community understands that meteorological conditions are not restricted to the boundaries of a flight information region (FIR) and that there is a need to provide a harmonized assessment of meteorological conditions irrespective of FIR boundaries. This perspective became most apparent in recent years with the provision of volcanic ash information; where there was a lack of information on the location of the hazard in some areas compounded by occasional inconsistency of information from different providers, covering adjacent areas. Within the international airways volcano watch (IAVW) these deficiencies have been well documented, with a wide array of remedial system changes implemented or being implemented. However, the international community has not yet

²⁶ Including inter-alia the achievement of a robust global network based on the principles of Service Oriented Architecture (SOA).

implemented the necessary system and product changes needed for other hazardous meteorological conditions.

If States are to respond to user demands for the provision of better aeronautical meteorological services, there is a need to change how these services are provided in support of the vision provided at the AN-Conf/12. For example, if States fail to recognize these changes, operators may look to other sources to obtain the necessary information to support their performance based operations. While it is recognized that fundamental services must continue to be provided by States, there is a need to identify which services belong to the State to support operations within their FIR, and which services are required for situations where meteorological conditions are transparent to FIR boundaries

1.8 Working Relationships

To ensure the success of the strategic plan there is a need to develop a co-ordinated working relationship with various organizations, service providers and users of services that includes but not necessarily defines all the stakeholders, including:

- WMO — World Meteorological Organization.
- IATA — International Air Transport Association.
- CANSO — Civil Air Navigation Services Organisation.
- IFALPA — International Federation of Airline Pilots' Associations.
- IFATCA — International Federation of Air Traffic Controllers' Associations.
- ISO — International Organization for Standardization.
- States in general (States in need of assistance, States able to host RHWACs, States likely to be able to provide other assistance, VAAC and TCAC host States)
- ICAO Regional offices.
- Particular States with capability and capacity to serve as a regional centre.

Discussion on Implementation

Consideration will be needed as to the assignment of an expert group to manage the process. This group may need to have overall management responsibilities for the system, reporting on a regular basis to the Secretariat or to the Air Navigation Commission (ANC). Its work will need to include the implementation of appropriate funding systems.

It is recognized that States will continue to have an important role in support of the operation of the intended regional hazardous weather centre concept. States will need to:

- (a) ensure that they provide, through their respective MWOs and requisite communications systems and protocols, local information²⁷ including special air-reports to the regional hazardous weather advisory centres, and eventually the regional hazardous weather centres, in a timely fashion;
- (b) continue to provide so-called flight following services through their respective MWOs, including the relay as appropriate of hazardous meteorological conditions information, monitoring of the

²⁷ Local information includes data and information from any remote sensing and satellite reception capabilities not directly accessible by the Regional Centres.

regional hazardous weather advisory centres and eventually the regional hazardous weather centre products with formal routine and special feedback to the centres²⁸;

- (c) where possible, provide routine evaluation of the hazardous weather information provided by the regional centres; and
- (d) continue to undertake the specified tasks required in the volcanic ash advisory and tropical cyclone advisory schemes.

MWOs would continue with all other specified requirements as currently set out in Annex 3.

In implementing the strategy care needs to be taken to ensure the voice of all States is represented on the referred expert group. In this regard, it is suggested that there be particular representation from a State or several States in each ICAO Region, and service provider and user representative bodies to supplement the expertise required (including WMO experts). The experience and capabilities of States involved in the development and operation of TCAC, WAFC and VAAC responsibilities should also be represented on the expert group either through membership and/or defined relationships.

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²⁸ Routine feedback to the Regional Centre would include the routine provision of validation and complementary real-time information. Special feedback would include real-time quantitative and qualitative advice on specific quality matters with regard to the Regional Centre products.

APPENDIX E**PLAN FOR THE COST RECOVERY AND GOVERNANCE SUPPORTING REGIONAL
HAZARDOUS WEATHER ADVISORY CENTRES****Overall Objective**

To develop a plan for the future governance and equitable cost recovery of a regional SIGMET advisory system for hazardous meteorological conditions for international civil aviation.

This plan and associated discussion is expected to support recommended actions concerning aeronautical meteorological service provision arising from ICAO's 12th Air Navigation Conference (AN-Conf/12 held 19 to 30 November 2012), and, importantly, the strategic statement relating to the provision of information on hazardous meteorological conditions to international civil aviation from regional advisory centres.

This paper details some of the issues relating to the future governance and cost recovery arrangements of the regional hazardous weather advisory centres (RHWAC) and provides an initial plan for development to assist discussion at the forthcoming Meteorology (MET) Divisional Meeting in July 2014.

The plan is intended to support and align with the programme and timing of the aviation system block upgrades (ASBUs)²⁹.

Refer: Agreed Action 5/3, Meteorological Warnings Study Group (METWSG), 5th Meeting, Montréal, 20 to 21 June 2013.

Problem Definition**Strategy Linkage**

The concurrent strategic paper on the Future Provision of Information on Hazardous Meteorological Conditions (deriving from the Agreed Action 5/1, METWSG, 5th Meeting) sets out that there is a significant and long standing issue regarding deficiencies in some ICAO Regions concerning SIGMET provision and harmonisation within the current State Meteorological Watch Office (MWO) flight information region (FIR)-based system.

Some States have a chronic lack of capacity³⁰ to fully meet their Annex 3 – *Meteorological Service for International Air Navigation* responsibilities. In particular, some smaller developing States have difficulty with SIGMET provision. Some developed States also have significant problems in this area³¹. These difficulties result in particular MWOs not being able to issue SIGMETs in a timely, reliable, or accurate manner.

A three phased remedial strategy is proposed in response to long voiced concerns from users (IATA and others) regarding the safety and efficiency of operations in areas where SIGMETs are rarely, if ever, issued for hazardous meteorological conditions.

Key Issue

²⁹ ASBUs methodology contained in the Fourth Edition (2013) of ICAO's Global Air Navigation Plan (GANP) (Doc 9750-AN/963). The ASBUs provide target availability timelines for a series of operational improvements – technological and procedural – that will eventually realize a fully-harmonized global air navigation system.

³⁰ Capacity includes people, funding, expertise and underpinning infrastructure.

³¹ The acute lack of capacity of some States to meet many Annex 3 responsibilities regarding SIGMET issuance was emphasised during a SIGMET trial conducted by the METWSG in April to July 2011. This trial was aimed at testing the feasibility of regional SIGMET advisory centres (RSAC) assisting MWOs to issue SIGMETs by providing them with SIGMET advisory information.

There is currently no specific guidance or systems available through ICAO and WMO to assist in the funding or governance of regional centres providing advisory services on hazardous meteorological conditions.

The Plan

In direct relation to the *Statement of Strategic Intent* in the concurrent paper, *Future Provision of Information on Hazardous Meteorological Conditions*:

Assign an ICAO Expert Group by September 2014

The first objective will be to assign an ICAO expert group to have overall management responsibilities for developing the RHWAC scheme. The expert group would report on a regular basis to the Secretariat or directly to the Air Navigation Commission (ANC). Its work will need to include:

- (a) the development and implementation of permanent governance arrangements by mid-2015; and
- (b) the development and implementation of appropriate funding systems by mid- 2015.

The voice of key States should be represented on the expert group. In this regard, it is suggested that there be particular representation from a State or several States in each ICAO Region, and service provider and user representative bodies to supplement the expertise required (including WMO experts). The experience and capabilities of States involved in the development and operation of tropical cyclone advisory centre (TCAC), world area forecast centre (WAFC) and volcanic ash advisory centre (VAAC) responsibilities should also be represented on the expert group either through membership and/or defined relationships. The ICAO Secretariat will need to ensure that relevant ICAO financial and economic expertise is available (such as from within the Air Transport Bureau).

Develop and Implement Governance Arrangements by mid-2015

In developing robust governance arrangements, the expert group will need to consider, taking into account those matters considered in this paper:

- (a) all technical management issues in establishing the RHWACs;
- (b) establishment of formal governance processes within the ICAO framework, documentation and reporting;
- (c) product validation/verification processes and routine assessment and reporting; and
- (d) financial management relationships, accounting and reporting procedures.

Develop and Implement of Appropriate Funding Systems by mid-2015

In developing robust funding systems, the expert group will need to consider taking into account those matters considered in this paper:

- (a) all possible alternatives, including those set out in this paper;
- (b) current cost recovery systems and guidance from both ANSPs and NMHSs that cover FIRs outside respective State territories;
- (c) extensive consultation and discussion with key stakeholders and possible third party assistance (for example, World Bank, Regional Development Banks);
- (d) the most expeditious method for accounting, reviewing and reporting on revenue and allocation to the RHWACs; and
- (e) the most expeditious method for RHWACs to report financial estimates, budgets and financial performance.

Complete all arrangements by the end of 2015

The target for ensuring good governance and funding systems are in place is the end of June 2015. It is expected that this will enable the first RHWACs to be established on a firm foundation within the time-scale set out in the *Statement of Strategic Intent* for regional centres – i.e. by the end of 2015.

As other regional centres are progressively developed they will have an already operating governance and financial system to engage, making the process straight forward and largely of a technical nature.

Background Considerations

This section sets out background information taken into account in the derivation of the plan for funding and governance of the future provision of advisory information on hazardous meteorological conditions.

ICAO Strategic Objectives

ICAO has established three Strategic Objectives for years 2011, 2012 and 2013:

- (a) Safety: Enhance global civil aviation safety;
- (b) Security: Enhance global civil aviation security; and
- (c) Environmental Protection and Sustainable Development of Air Transport: Foster harmonized and economically viable development of international civil aviation that does not unduly harm the environment.

In years 2014, 2015 and 2016 the number of strategic objectives of ICAO will increase to five. Ten key air navigation policy principles³² are contained in the GANP, intended to guide global, regional and State air navigation planning consistent with ICAO's strategic objectives.

Existing International Guidance

Extensive ICAO guidance on cost recovery is provided in *the Manual on Air Navigation Services Economics* (Doc 9161). This detailed manual sets out the ICAO policy on cost recovery and provides a robust array of perspectives that need to be taken into account in designing cost recovery systems. Appendix 3 of Doc 9161 details the guidance for determining the costs of aeronautical meteorological services. Additionally, ICAO's *Policies on Charges for Airports and Air Navigation Services* (Doc 9082) provides guidance on cost recovery.

WMO provides a *Guide to Aeronautical Meteorological Services Cost Recovery: Principles and Guidance* (WMO Publication No. 904). This publication contains additional information on the principles of cost allocations for National Meteorological Services and other providers of meteorological services to aviation, but currently does not provide guidance on multi-State/multi-FIR based cost recovery mechanisms.

Existing Regional Schemes

At present, within the ICAO framework there are:

- (a) nine volcanic ash advisory centres (VAACs) (namely Anchorage, Buenos Aires, Darwin, London, Montreal, Tokyo, Toulouse, Washington and Wellington) as part of the international airways volcano watch (IAVW)
- (b) seven tropical cyclone advisory centres (TCACs) (namely Darwin, Honolulu, La Réunion, Miami, Nadi, New Delhi and Tokyo), and

³² Refer Doc 9750-AN/963 — 2013-2028 Global Air Navigation Plan.

- (c) two world area forecast centres (WAFCs) (namely London and Washington) as part of the world area forecast system (WAFS)

In addition, there is the ICAO Satellite Distribution System (SADIS) that provides OPMET information and WAFS forecasts to States/users in the ICAO EUR, AFI, MID and western part of the ASIA/PAC Regions.

With the exception of the SADIS, which has a governance and cost recovery arrangement in place, there are no regional cost recovery arrangements in place for any of the other regional or global centres referred to above.

Currently the IAVW, WAFS and SADIS all have a governance structure in place by way of ICAO operations groups – namely the IAVWOPSG, WAFSOPSG and SADISOPSG – which report to the Air Navigation Commission and/or Planning and Implementation Regional Groups (PIRGs) of ICAO on a routine basis. These operations groups consist of, inter alia, the provider States, States who make use of the services provided, airline users represented by IATA, and flight crew users represented by IFALPA. ICAO provides the Secretariat support for these operations groups.

These operations groups currently meet on a 12- or 18-month cycle and each has a similar agenda that includes:

- (a) review of associated regional and/or global ICAO provisions;
- (b) operation of the centres or systems;
- (c) development of the centres or systems; and
- (d) long term development and implementation issues.

WMO arranges for the governance for the TCACs. A technical co-ordination meeting involving all of the TCAC provider States currently takes place once every three years, however a number of regional committees (within the construct of the WMO Regional Associations) take place during the intersession period. There are no airline or flight crew user representatives on these particular WMO groups, however the ICAO Secretariat attends where resources allow.

Known Issues

Each State is responsible for the provision or facilitation, and funding of its meteorological service. Some States contract out the work and rely on those contractors to recover costs through third party mechanisms. Others meanwhile fund service directly from taxes or through air traffic services (ATS) and airspace levies and charges. In many cases, airlines and operators have little input into how the State delivers the service and how it is funded, leading to a general lack of transparency.

Currently States that provide regional and global meteorological centres (such as the TCACs, WAFCs and VAACs alluded to above) have taken responsibility for funding and resourcing. Where cost-recovery takes place, airspace users receiving en-route air navigation services (ANS) within the particular State's FIR(s) may be charged directly by the ATS provider or indirectly through other charging mechanisms bearing on airline operations. There is no international or regionally common scheme for the collection of revenue to support regional and global meteorological centres.

The demands on providing more accurate regional or global forecasts require constant improvements to the provider State's capability. This includes increasingly expensive computing capability for numerical weather prediction (NWP), data post-processing, as well as more sophisticated production software development. In this regard, States providing regional and global meteorological centre operations have generally noted that that there is increasing scrutiny being applied to these costs by operators.

The additional costs of providing such services for aviation can no longer be considered marginal or just a bi-product of the routine activities. Staff resources and infrastructure costs to provide these often complex and demanding services are needed; in addition, they also have to be tested and exercised on a regular basis.

An important aspect for any regional centre is the need to share information with neighbouring States and other centres³³. Operationally meeting this requirement, let alone the cost, may well be above and beyond what the provider State would normally be required to undertake if it was not a regional centre.

Generally speaking, airlines/operators overflying the regional centres area of operation but not the provider State FIRs currently do not contribute to the cost of the provision of the particular service. In a regionalised scheme, this highlights that current cost State/FIR-based recovery methodologies would be materially inequitable.

Discussion

Management and Governance

It is considered that similar arrangements of governance to the existing regional and global centres alluded to above could be utilised for the RHWACs - a global group of experts advising ICAO on the operation of the service and its effectiveness in meeting user requirements.

Careful consideration is needed as to the makeup of the ICAO expert group(s) that would oversee the work of the RHWACs, noting the need for a variety of expertise not just in meteorology but airline operations, air traffic management (ATM) and cost recovery. The expert group would need to ensure best practices are developed and shared between the RHWACs.

More local discussions relating to the day-to-day operation of the RHWACs should take place at the ICAO regional MET sub-group meetings (or equivalent) of the PIRGs, since these meetings would also allow States and users within the ICAO Region to have the opportunity to influence the development of the service and to propose changes to the requirements to particular or all RHWACs.

Governance structures must be in place to manage the establishment of the RHWACs. These governance structures (expert group(s)) would need to;

- detail the specific regional requirements (based on global ICAO provisions);
- arrange appropriate user consultation, produce guidance and usability guides for the products being provided;
- set out the performance indicators as agreed with the users;
- detail the meteorological information required from States (for example, observations);
- ensure there is a transparent costing, budgeting and long term investment plan in place;
- assist in the running (or development) of a cost recovery scheme; and
- review of performance, based on the performance indicators.

During implementation, governance could reside with a more local group (for example, a PIRG) that assists the State providing the RHWAC by providing guidance on policy and strategy during its initial operation. However, recognising the need for harmonized practices it is suggested that during the implementation phase a number of best practices workshops are held for the RHWACs.

The alternative is for a global expert group to oversee the establishment of the RHWACs as currently defined and as may be requested by the PIRGs.

³³ Including, for example, pilot reports, satellite information and other observations.

It is noted that users have expressed a need for consistency between RHWACs, one aspect of the governance expert groups is to ensure that the advisory products are provided uniformly and in a similar manner and that change management principles are applied. Also critical to the work of the RHWACs will be the development and subsequent agreement of a common set of key performance indicators (KPIs) to ensure that the RHWACs meet the quality standards required by users.

It is considered that there are no additional liability issues for a State since all the information provided by the RHWAC is provided as guidance material only.

Funding

While in theory it can be relatively easy to determine what type of cost recovery system should be in place, practically this is not the case. There are complicated political considerations and administration arrangements that would need to be put in place and any such scheme also needs to be fair and enforceable.

The following excerpt from ICAO's *Policies on Charges for Airports and Air Navigation Services* (Doc 9082) provides details for the charges for air navigation services used by aircraft when not over the provider State. A similar policy could be developed for provision of meteorological services.

"53. The Council observes that the providers of air navigation services for international use may require all users to pay their share of the cost of providing them regardless of whether or not the utilization takes place over the territory of the provider State. Accordingly, wherever a State has accepted the responsibility for providing route air navigation services over another State, over the high seas, or in an airspace of undetermined sovereignty (in accordance with the provisions of ICAO Annex 11 — *Air Traffic Services* to the *Convention on International Civil Aviation* and *Regional Air Navigation Agreements* approved by the Council), the State concerned may levy charges on all users for the services provided. A State may delegate to another State or to an organization the authority to levy such charges on its behalf.

54. The Council also notes that the collection of air navigation services charges in cases where the aircraft does not fly over the provider State poses difficult and complex problems. It is for the States to find the appropriate kind of machinery on a bilateral or regional basis for meetings between provider States and those of the users, aiming to reach as much agreement as possible concerning the facilities and services provided, the charges to be levied, and the methods of collecting these charges."

Whilst the direct costs of provision will be relatively straightforward to identify, the allocation of additional core costs (i.e. infrastructure and underpinning services) will be more difficult. It is likely that additional guidance on the subject would need to be provided to assist States in order that a standardised allocation of costs is undertaken by the RHWAC provider States. This guidance would need to ensure States undertaking the operation of an RHWAC understand the need for transparency in determining the associated core costs.

Conversely, it is recognised that if an RHWAC were to have multiple functions, for instance if they were responsible for tropical cyclone, volcanic ash and other hazardous phenomena, this would reduce costs for training/competencies, administration for recovering costs, staff costs, data transfer, etc.

5.2.1 Cost Recovery Options

Creating a cost recovery arrangement for the RHWACs will provide an opportunity for users to influence the development work and have knowledge of the quality of information being provided. This will also allow users to compare the output from the RHWACs and see which provide quality services in a cost effective manner whilst recognising that the costs of providing the RHWAC service will vary due to the cost of living and other factors.

While the prospect of no cost recovery mechanisms is not ideal, this does not mean that a State hosting (providing) an RHWAC must cost recover. An RHWAC provider State could elect to meet costs from its own internal budgetary process.

5.2.1.1 No Regional Cost Recovery

In the past, when the provision of regional based advisory services were considered part-and-parcel of the National Meteorological Service (NMS) it could be argued that the costs of provision were relatively low and therefore the costs were “*de minimis*” (i.e. the effort to collect the charges does not justify the means since its effect on the en-route rate was low). However, as noted above, the costs of provision of regional and global meteorological services are increasing. The other possible concern to consider is that while it might be perfectly feasible for a large or well-developed State to bear this cost, this might not be the case for smaller or developing States. This could result in discouraging important investment in capability.

5.2.1.2 Airspace Users / States contract directly with the State providing the regional service

Airline operators that conduct flights through a region being supplied with SIGMET advisories from a RHWAC would contract directly with the State providing the RHWAC service. In addition, there would be a facility for States within the region to make contractual arrangements with the RHWAC provider State in order that the NMS and other agencies (e.g. the ANSP) could receive the information.

This option is complex in that the role of contract Law between the RHWAC provider State and the airlines / users could be quite fraught, and expensive to administer. There is also the likelihood that either non-State based operators are denied access to the services or that a number of users do not pay but receive the information from other sources.

5.2.1.3 Regional Cost Recovery Scheme

The SADIS cost recovery scheme alluded to above is a good example of a regional cost recovery scheme, whereby each year the provider State establishes the costs of providing the service; this cost is then shared by the States that make use of the service according to usage information provided by ICAO. Such a model could be used for regional cost recovery of RHWAC. It is noted that countries designated by the United Nations as a Least Developed Country are not required to pay any share of the costs. A similar model is used in Europe for the central collection of en-route charges for regional institutions (i.e. Eurocontrol).

This option requires the support of all States in a given ICAO Region and would be open to argument as to the acceptance and/or proportionality of charges levied on each State.

5.2.1.4 Fee Collection

In the contemporary systems, the administration, record keeping and fee collection arrangements form a critical element for the success of such a scheme. In addition, any user - be it State or operator - that refuses to pay would almost certainly be able to receive the information from other sources. If substantial numbers of users do not pay then it is likely that the services provided from the RHWAC would be of lower quality since the resources and investment to maintain the service delivery at sustainable levels would not take place.

5.2.1.5 Third Party Alternative

From the discussion in this section it is clear that any State-based scheme to fund the RHWACs will be difficult to implement and manage due to complexity of relationships and State Law. An alternative to that approach is to use a method of third party funding. ICAO successfully administers the contributions from States (recovered from airlines) to fund the provision of certain international services through its joint financing program;

- Air Navigation Services in Greenland and Iceland (DEN/ICE),
- North Atlantic Height Monitoring System (HMS)

5.2.2 Summary

Any future cost recovery mechanism should ensure that there is:

- clear description of objectives and benefits;
- identification of facilities and services to be jointly financed;
- definition of the responsibilities of the different partners;
- simplicity and flexibility of the arrangements; and
- equitable recovery of costs through charges consistent with ICAO's policies on charges
- alignment with the principles of *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082)

5.3 Working Relationships

To ensure the success of the strategic plan there is a need to develop a co-ordinated working relationship with various organizations, service providers and users of services that includes but not necessarily defines all the stakeholders, including:

- WMO — World Meteorological Organization.
 - IATA — International Air Transport Association.
 - CANSO — Civil Air Navigation Services Organisation.
 - IFALPA — International Federation of Airline Pilots' Associations.
 - IFATCA — International Federation of Air Traffic Controllers' Associations.
 - ISO — International Organization for Standardization.
 - States in general (States in need of assistance, States able to provide RHWACs, States likely to be able to provide other assistance, VAAC and TCAC provider States)
 - ICAO Regional Offices.
 - Particular States with capability and capacity to serve as a regional centre.
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APÉNDICE F**RESULTADOS ESPERADOS DEL SISTEMA MUNDIAL DE PRONÓSTICOS DE ÁREA
EN APOYO DEL BLOQUE 3 DE LAS ASBU**

- Pronósticos conjuntos sobre peligros efectuados por múltiples miembros y totalmente integrados
 - Implantación de la base de datos WAFS, en la que se ingresará información meteorológica obtenida de múltiples modelos para producir pronósticos conjuntos sobre información meteorológica mundial
- Implantación de modelos espaciales y temporales de alta resolución que generarán mejores representaciones de la información meteorológica
- Provisión de un conjunto completo de datos relativos a información meteorológica que incluya fenómenos meteorológicos en ruta y que permita incorporar esa información en los sistemas de apoyo para la toma de decisiones en materia de planificación de vuelos, gestión de vuelos y gestión del tránsito aéreo (ATM)
- Información reticular y de pronósticos de tiempo significativo (SIGWX) totalmente automatizada
- Plena implantación de la gestión de la información de todo el sistema (SWIM) para acceso a los datos del WAFS
- Retiro de información elaborada por el WAFS y sistemas de difusión heredados

— FIN —