ORGANISATION DE L'AVIATION CIVILE INTERNATIONALE

ORGANISATION MÉTÉOROLOGIQUE MONDIALE

MET/14-WP/64
CAeM-15/Doc. 64
18/7/14

Réunion météorologie (MET) à l'échelon division (2014)

Commission de météorologie aéronautique
Quinzième session

Montréal, 7 – 18 juillet 2014

RAPPORT SUR LE POINT 2 DE L'ORDRE DU JOUR

(Tous les points de l'ordre du jour ont été examinés conjointement avec la quinzième session de la Commission de météorologie aéronautique de l'Organisation météorologique mondiale)

Le présent rapport sera soumis pour examen à la Commission de navigation aérienne et au Conseil de l'OACI ainsi qu'au Conseil exécutif de l'OMM. Les décisions de ces organes sur les recommandations de la réunion seront exposées dans un supplément au rapport de la réunion, qui sera publié en temps utile.

14-2087

Point 2 : Améliorer la sécurité et l'efficacité de la navigation aérienne internationale en renforçant la fourniture de l'assistance météorologique

2.1 : Renforcement de la fourniture de l'assistance météorologique actuelle pour appuyer la prise de décisions opérationnelles stratégiques, pré-tactiques et tactiques d'aujourd'hui (notamment le module ASBU B0-AMET)

2.1.1 La réunion examine des propositions relatives au renforcement de l'actuel système mondial de prévisions de zone (SMPZ), des éléments du service fixe aéronautique (SFA) et les progrès réalisés dans d'autres domaines depuis la dernière réunion météorologie (MET) à l'échelon division, tenue en 2002 (MET/02). Par ailleurs, elle prend acte de neuf notes d'information concernant le sous-point 2.1 de l'ordre du jour.

Assistance météorologique aéronautique aux aérodromes et en région terminale, y compris renseignements OPMET

2.1.2 La réunion se félicite des progrès considérables réalisés depuis la réunion MET/02, en particulier l'automatisation des systèmes d'observation d'aérodrome et l'introduction de prévisions d'aérodrome à période de validité de 30 heures à certains aérodromes.

Le système mondial de prévisions de zone (SMPZ), le système de diffusion par satellite du service fixe aéronautique et les services basés sur l'Internet

2.1.3 La réunion note avec approbation que, depuis la réunion MET/02, d'importantes améliorations ont été apportées dans le cadre du programme du SMPZ, dont l'accroissement de la résolution temporelle et spatiale des prévisions en altitude aux points de grille mondiales du SMPZ (transition d'intervalles de temps de 6 heures à des intervalles de temps de 3 heures, transition d'une grille horizontale amincie de 1,25 degré à une grille horizontale ordinaire [non amincie] de 1,25 degré et augmentation de la résolution verticale, en particulier aux altitudes de croisière), ainsi que l'élaboration et la mise en œuvre opérationnelle de prévisions mondiales aux points de grille du SMPZ concernant le givrage, la turbulence et les cumulonimbus.

2.1.4 La réunion convient que les modifications à apporter au SMPZ pendant la période 2013 à 2018 devraient être axées sur des améliorations des prévisions mondiales aux points de grille du SMPZ concernant le givrage et la turbulence. À cet égard, elle examine et approuve les principes à utiliser (sous forme de livrables) comme base pour les futures évolutions du SMPZ à l'appui du module B0-AMET de la méthode de mise à niveau par blocs du système de l'aviation (ASBU). La réunion formule donc la recommandation suivante :

Recommandation 2/1 — Développement du SMPZ à l'appui de la méthode ASBU jusqu'en 2018

Il est recommandé que l'OACI, par l'intermédiaire d'un groupe d'experts compétent, utilise les principes énoncés dans les livrables énumérés en appendice comme base pour le développement futur du système mondial de prévisions de zone (SMPZ) à l'appui du module B0-AMET de la méthode de mise à niveau par blocs du système de l'aviation (ASBU) figurant dans le *Plan mondial de navigation aérienne* (GANP) (Doc 9750).

2.1.5 En ce qui a trait au système SFA de diffusion par satellite d'informations relatives à la navigation aérienne (SADIS), qui sert à diffuser les renseignements OPMET mondiaux et les prévisions du SMPZ aux États et aux usagers autorisés, ou à les mettre à leur disposition, la réunion note les importants progrès accomplis depuis la réunion MET/02; ils sont à l'origine du système de diffusion par satellite de deuxième génération du SADIS (SADIS 2G) et du service FTP sécurisé basé sur l'Internet du SADIS qui sont utilisés en exploitation aujourd'hui par plus de 180 usagers autorisés dans près de 110 États des Régions Europe (EUR), Moyen-Orient (MID) et Afrique-Océan Indien (AFI) de l'OACI et de la partie occidentale de la Région Asie-Pacifique (APAC). La réunion estime que, comme il s'agit d'un service dont le coût est entièrement recouvrable, il faut veiller à ce que le SADIS continue de fonctionner en répondant aux attentes des usagers et à ce que son développement cadre avec l'évolution du GANP et de la méthode ASBU qu'il contient. De plus, la réunion convient que ce développement, ainsi que celui du service de fichiers Internet du SMPZ (WIFS) desservant les Amériques et la partie orientale de la région Asie-Pacifique, devrait tenir compte du futur système de gestion globale de l'information (SWIM) et des travaux des autres groupes d'experts de l'OACI chargés d'élaborer le système SWIM. La réunion formule donc la recommandation suivante :

Recommandation 2/2 — Fonctionnement et développement du système de diffusion par satellite du service fixe aéronautique et des services basés sur l'Internet

Il est recommandé qu'un groupe d'experts compétent de l'OACI soit d'urgence chargé de veiller à ce que le système de diffusion par satellite du service fixe aéronautique (SFA) pour les informations relatives à la navigation aérienne (SADIS), le FTP sécurisé du SADIS et les services basés sur Internet du service de fichiers Internet du SMPZ (WIFS) continuent de répondre aux attentes des usagers et à ce qu'ils soient développés d'une manière qui cadre avec le *Plan mondial de navigation aérienne* (Doc 9750), y compris :

a) l'examen du rôle du SADIS et du WIFS dans le futur environnement de gestion globale de l'information (SWIM) sur lequel le système de gestion du trafic aérien interopérable à l'échelle mondiale sera basé ; et,

b) l'alignement avec les futures activités à entreprendre par l'OACI dans le domaine de la gestion de l'information.

2.1.6 En ce qui concerne l'avenir de la diffusion par satellite du SADIS 2G au-delà de 2015, la réunion pense comme le Groupe de l'exploitation du SADIS (SADISOPSG) que le SADIS 2G devrait être maintenu au-delà de 2015 mais seulement jusqu'en novembre 2019 au plus tard, et conclut qu'il ne serait pas viable d'investir dans un renforcement du système dans l'intervalle. La réunion formule donc la recommandation suivante :

Recommandation 2/3 — Abandon de la diffusion par satellite du SADIS 2G et essais formels, sur l'AMHS, de l'échange de renseignements OPMET mondiaux et de prévisions mondiales du SMPZ

Il est recommandé que l'OACI, par l'intermédiaire d'un groupe d'experts compétent, soit chargée de :

a) prendre les mesures nécessaires pour faire en sorte que la diffusion par satellite du SADIS 2G soit maintenue au-delà de 2015 mais non après novembre 2019 ;

b) prier instamment les États/usagers concernés qui ne l'ont pas encore fait de passer à l'utilisation opérationnelle du service FTP sécurisé du SADIS pendant l'intervalle visé à l'alinéa a) ci-dessus ; et

c) procéder d'urgence à des essais formels, sur le système de messagerie ATS (AMHS), de l'échange de renseignements OPMET mondiaux et de prévisions du système mondial de prévisions de zone (SMPZ), en vue de déterminer les possibilités et les spécifications minimales nécessaires à la diffusion de telles données aux États/usagers dans l'avenir.

Veille des volcans le long des voies aériennes internationales (IAVW), questions connexes relatives au dégagement de matières radioactives dangereuses dans l'atmosphère et météorologie de l'espace

2.1.7 La réunion constate les importantes améliorations intervenues depuis la réunion MET/02 dans le cadre de la veille des volcans le long des voies aériennes internationales (IAVW), notamment dans l'observation, la détection et le compte rendu en temps réel ou quasi-réel des éruptions volcaniques et des cendres volcaniques dans l'atmosphère ainsi que dans la prévision du déplacement et de la dispersion des cendres volcaniques. Elle note par ailleurs que certaines de ces améliorations ont été suscitées en particulier par les éruptions majeures des volcans islandais Eyjafjallajökull et Grimsvötn, en 2010 et 2011, respectivement, et du Puyehue-Cordón Caulle, au Chili, en 2011. Elle note que l'OACI, en étroite collaboration avec l'OMM, a créé une Équipe spéciale internationale sur les cendres volcaniques (IVATF), qui a travaillé en parallèle avec le Groupe de l'exploitation de la veille des volcans le long des voies aériennes internationales (IAVWOPSG) entre 2010 et 2012 afin d'aider à accélérer les activités sur diverses questions scientifiques, techniques et opérationnelles qui avaient été mises en évidence par ces éruptions. De plus, la réunion note avec satisfaction que l'Organisation météorologique mondiale (OMM) et l'Union géodésique et géophysique internationale (UGGI) ont créé un Groupe consultatif scientifique mixte pour les cendres volcaniques (VASAG) en mars 2010, juste avant l'éruption de l'Eyjafjallajökull, et que le VASAG a joué un rôle déterminant dans la fourniture d'indications scientifiques à l'IVATF et à l'IAVWOPSG.

2.1.8 La réunion constate que l'IAVWOPSG a commencé l'élaboration d'une feuille de route pour l'IAVW et qu'il a également commencé à élaborer des concepts opérationnels pour l'information sur les dégagements de matières radioactives dans l'atmosphère et la météorologie de l'espace, afin d'aider à comprendre comment la fourniture de l'assistance évoluera au cours des prochaines années pour appuyer le système émergent de gestion mondiale du trafic aérien.

Information sur les conditions météorologiques dangereuses, y compris les dangers en route

2.1.9 La réunion note que la tâche principale du Groupe d'étude sur les avertissements météorologiques (METWSG), créé par l'OACI en 2007, a été d'examiner les dispositions de l'Annexe 3/Règlement technique [C.3.1] relatives à la teneur et à la communication des renseignements SIGMET afin de répondre aux besoins en évolution de l'exploitation aérienne et de résoudre des problèmes tenaces de mise en œuvre des SIGMET que connaissaient de nombreux États. À ce sujet, elle constate avec plaisir que le METWSG a procédé à un essai de fourniture de renseignements consultatifs SIGMET en 2011 dans la Région AFI et une partie de la Région APAC, avec une participation importante de l'Afrique du Sud, de la Chine et de la France, qui ont joué le rôle de centres d'avis SIGMET pendant l'essai. L'essai ayant donné des résultats positifs, la réunion prend note d'une proposition relative à l'établissement d'un système régional d'avertissement de conditions météorologiques dangereuses (examiné dans le cadre du point 2.2 de l'ordre du jour).

2.1.10 La réunion note aussi d'autres éléments nouveaux connexes provenant du METWSG, notamment une proposition d'amendement de l'Annexe 3/Règlement technique [C.3.1] visant à améliorer en particulier l'établissement des SIGMET et des renseignements AIRMET concernant des conditions météorologiques dangereuses, y compris les dangers en route (examiné dans le cadre du point 5.1 de l'ordre du jour).

Point 2 : Améliorer la sécurité et l'efficacité de la navigation aérienne internationale en renforçant la fourniture de l'assistance météorologique

2.2 : Information météorologique intégrée renforcée pour appuyer la prise de décisions opérationnelles stratégiques, pré-tactiques et tactiques à partir de 2018 (notamment le module ASBU B1-AMET)

2.2.1 Dans le contexte du renforcement de l'assistance météorologique aéronautique à partir de 2018, la réunion examine des propositions relatives au renforcement du système mondial de prévisions de zone (SMPZ) et de la veille des volcans le long des voies aériennes internationales (IAVW) et à la fourniture de renseignements sur les phénomènes météorologiques spatiaux, les dégagements de matières radioactives et de produits chimiques toxiques et autres phénomènes météorologiques dangereux. De plus, elle prend acte de quatorze notes d'information relatives à ce sous-point de l'ordre du jour.

Considérations générales pour l'élaboration de futures spécifications relatives à l'information météorologique aéronautique

2.2.2 La réunion appuie, en principe, l'évolution du SMPZ et de l'IAVW existants et la poursuite de l'élaboration de dispositions concernant l'information de météorologie de l'espace, les dégagements de matières radioactives et de produits chimiques toxiques et autres phénomènes météorologiques dangereux. Elle est cependant d'avis qu'il faudrait consacrer un plus ample examen à l'évolution générale de la fourniture de l'assistance météorologique aéronautique dans le contexte d'un environnement du transport aérien en mutation, et sur l'élaboration d'un cadre de dispositions sur l'assistance aux niveaux local, sous-régional, régional, multirégional et global. Dans un tel cadre, la réunion note que les dispositions pourraient appuyer le concept d'avoir des collectivités d'usagers à différents niveaux – p. ex. usagers de l'espace aérien individuels, opérations de compagnies aériennes et divers services ou fonctions de la circulation aérienne – tout en veillant à assurer que l'échange d'information MET basée sur les performances soit d'un bon rapport coût-efficacité, souple et proportionné à son utilisation opérationnelle et qu'il réponde aux objectifs du Bloc 1 de la méthode de mise à niveau par blocs du système de l'aviation (ASBU) figurant dans le *Plan mondial de navigation aérienne* (GANP) (Doc 9750) et autres objectifs connexes. La réunion convient qu'il est impératif que la gestion et la gouvernance futures du système de météorologie aéronautique desservant la navigation aérienne internationale soient évaluées, avec une identification claire des changements nécessaires. Il est noté en outre que, puisque le développement de la technologie fait partie intégrante des services attendus à l'avenir, il continuera d'être important que la fourniture des services demeure collaborative et inclusive. La réunion formule en conséquence la recommandation suivante :

Recommandation 2/4 — Réexamen du cadre de fourniture du service d'information MET pour tenir compte des objectifs du GANP

Il est recommandé que l'OACI, par l'intermédiaire d'un groupe d'experts approprié et en étroite coordination avec l'OMM, à l'appui des objectifs généraux de sécurité et d'efficacité, soit instamment priée :

a) de réexaminer le cadre de fourniture du service d'information MET existant établi dans l'Annexe 3 — *Assistance météorologique à la navigation aérienne* *internationale*, en prenant en considération les besoins émergents des usagers, notamment les services de la circulation aérienne/gestion du trafic aérien, pour une information MET homogène, cohérente, précise, digne de foi et adaptée aux objectifs poursuivis, comme le veulent les spécifications relatives aux exigences de performances à l'appui des objectifs généraux du *Plan mondial de navigation aérienne* (GANP) (Doc 9750) ;

b) de veiller à ce que les priorités initiales du réexamen, qui devrait être achevé pour 2016, se conjuguent avec :

1) le développement futur du système mondial de prévisions de zone (SMPZ), de la veille des volcans le long des voies aériennes internationales (IAVW) et de dispositions relatives à l'information concernant les phénomènes météorologiques spatiaux et le dégagement de matières radioactives dans l'atmosphère ;

2) l'élaboration et la mise en œuvre d'un système consultatif régional pour certaines conditions météorologiques dangereuses en route pour les États où existent des carences en matière de SIGMET ;

3) un appui MET pour des opérations basées sur trajectoire en général et la prise de décisions en collaboration, notamment aux niveaux des aéroports et des réseaux ;

4) l'élaboration d'éléments d'orientation à l'intention des États sur la façon dont ils pourront s'acquitter de leurs obligations OACI dans le contexte de l'assistance MET locale, sous-régionale, régionale, multirégionale et globale, y compris les considérations de recouvrement des coûts et de gouvernance.

c) de veiller à ce que les résultats de ce réexamen soient pris en considération lors de la mise à jour du GANP et des modules de mise à niveau par blocs du système de l'aviation (ASBU) pertinents ;

d) de veiller à ce que des principes directeurs respectant les mandats de l'OACI et de l'OMM soient élaborés à l'intention des États, afin de faciliter la fourniture d'assistance MET inclusive aux échelons local, sous-régional, régional, multi-régional et global lorsque c'est nécessaire, et que des collectivités d'usagers locales, sous-régionales, régionales, multirégionales ou globales pourraient utiliser cette information dans leurs opérations.

2.2.3 Outre ce qui précède, la réunion examine les besoins des pilotes, expressément dans le contexte des besoins des usagers pendant et après le passage à la fourniture de l'information météorologique aéronautique sous forme numérique, comme l'envisage le GANP. À cet égard, la réunion note un certain nombre de problèmes, liés en particulier à la visualisation de cette information, qui seront examinés de façon plus poussée dans le contexte des considérations d'automatisation et de facteurs humains (abordées au titre du sous-point 2.4 de l'ordre du jour).

Système mondial de prévisions de zone (SMPZ)

2.2.4 La réunion prend note des travaux qui ont été effectués dans l'élaboration d'une feuille de route pour faciliter l'élaboration de futures spécifications pour le SMPZ. En accord avec l'évolution future du GANP, la réunion note qu'il est prévu que la feuille de route évolue au cours des prochaines années pour assurer que les niveaux d'assistance répondent aux besoins actuels et futurs. Elle convient donc qu'il est vital, dans le cadre d'une approche holistique de la future fourniture d'assistance, que le SMPZ continue d'évoluer en accord avec le GANP avec un bon rapport coût-efficacité grâce à une gouvernance appropriée. Elle convient en outre que l'information produite dans le cadre du SMPZ devrait être intégrée dans le futur environnement de gestion globale de l'information (SWIM), y compris les formats de données interopérables à utiliser sur la base du modèle d'échange d'information météorologique (IWXXM) de l'OACI.

2.2.5 La réunion convient que les changements à apporter au SMPZ au cours de la période 2018-2023 du Bloc 1, et aussi ceux qui seront apportés au cours de la période 2023-2028 du Bloc 2, devraient être axés sur les principes énoncés à l'Appendice B. À cet égard, elle examine les principes à utiliser comme base pour de futurs développements du SMPZ, et en convient. La réunion formule en conséquence la recommandation suivante :

Recommandation 2/5 — Poursuite de l'élaboration du SMPZ

Il est recommandé qu'un groupe d'experts de l'OACI approprié, en étroite coordination avec l'OMM, soit chargé :

a) de poursuivre l'élaboration des spécifications relatives au système mondial de prévisions de zone (SMPZ), en conformité avec le *Plan mondial de navigation aérienne* (Doc 9750), y compris l'intégration de l'information produite par le SMPZ dans le futur environnement de gestion globale de l'information (SWIM) sur lequel s'appuie le système de gestion du trafic aérien interopérable mondialement ;

b) d'utiliser les principes indiqués par les livrables figurant à l'Appendice B comme base pour le développement futur du SMPZ dans les périodes des blocs 1 et 2 de la méthode de mise à niveau par blocs du système de l'aviation (ASBU).

Veille des volcans le long des voies aériennes internationales (IAVW)

2.2.6 La réunion note les importants renforcements de l'IAVW depuis la réunion Météorologie à l'échelon division (2002) (MET/02), notamment l'établissement d'une feuille de route pour faciliter les futures spécifications pour l'IAVW. Elle note que, en accord avec l'évolution future du GANP, il faut s'attendre à ce que la feuille de route pour l'IAVW évolue au cours des prochaines années pour assurer que les niveaux de service répondent aux besoins actuels et futurs. La réunion reconnaît donc qu'il est vital que l'IAVW continue d'évoluer en accord avec le GANP et que l'information produite dans le cadre de l'IAVW devrait être intégrée dans le futur environnement SWIM. Elle convient que la feuille de route figurant à l'Appendice B devrait être utilisée comme base pour l'élaboration des futures spécifications de l'IAVW. Elle formule en conséquence la recommandation suivante :

> **Recommandation 2/6 — Poursuite de l'élaboration de la veille des volcans le long des voies aériennes internationales (IAVW)**
>
> Il est recommandé qu'un groupe d'experts de l'OACI approprié, en étroite coordination avec l'OMM, poursuive l'élaboration des spécifications pour la veille des volcans le long des voies aériennes internationales (IAVW), en conformité avec le *Plan mondial de navigation aérienne* (Doc 9750), y compris l'intégration de l'information produite par le système dans le futur environnement de gestion globale de l'information (SWIM) sur lequel s'appuie le système de gestion du trafic aérien interopérable mondialement, en utilisant comme base la feuille de route figurant à l'Appendice C.

Météorologie de l'espace

2.2.7 La réunion prend note des travaux récents effectués par le Groupe de l'exploitation de la veille des volcans le long des voies aériennes internationales (IAVWOPSG) pour élaborer un projet de dispositions initiales à insérer dans l'Annexe 3/Règlement technique [C3.1] afin de répondre aux besoins d'information concernant les phénomènes météorologiques spatiaux, ceci impliquant la création de centres de météorologie de l'espace. Elle note en outre l'élaboration complémentaire d'un concept d'opérations pour des services d'information de météorologie de l'espace qui, en tant que document vivant, devrait évoluer en accord avec le GANP, lequel inclut de façon explicite la météorologie de l'espace comme convenu par la douzième Conférence de navigation aérienne de l'OACI (AN-Conf/12) en 2012, et note que l'information sur les phénomènes spatiaux devrait être intégrée dans le futur environnement SWIM.

2.2.8 Tenant compte de l'avis de l'OMM, et notamment de son Équipe de coordination inter-programmes sur la météorologie de l'espace (ICTSW), et d'autres intéressés, la réunion estime que des services d'information en météorologie de l'espace desservant la navigation aérienne internationale devraient être organisés au moyen de la création d'un nombre optimal de centres mondiaux (pour les tempêtes solaires et éruptions solaires, ainsi que pour les tempêtes géomagnétiques et les perturbations ionosphériques au stade des prédictions), et qu'ils devraient être complétés par un nombre optimal de centres régionaux (pour les tempêtes géomagnétiques et les perturbations ionosphériques au stade des observations). La réunion reconnaît que les rôles, les besoins et les possibilités des centres mondiaux et des centres régionaux (ainsi que le nombre optimal de centres) n'ont pas été entièrement élaborés.

Elle convient donc qu'il y a lieu de procéder à un plus ample examen de ce qui précède, et notamment de l'élaboration d'un processus pour la désignation de centres mondiaux et de centres régionaux, leur gouvernance (y compris le recouvrement des coûts pour la fourniture des services et les normes de compétence) et la durée de leur mandat. De plus, il est nécessaire que la compréhension générale de la manière dont l'information de météorologie de l'espace serait utilisée soit élaborée en détail et reflétée comme il convient dans une documentation appropriée pour la météorologie de l'espace.

2.2.9 Vu ce qui précède, la réunion convient de ne pas inclure le projet de dispositions initiales mentionné ci-dessus dans le projet d'Amendement n^{o} 77 de l'Annexe 3 (examiné au titre du point 5.1 de l'ordre du jour), en raison de la nécessité de poursuivre l'élaboration des besoins et des possibilités d'assistance et de tous éléments d'orientation supplémentaires connexes. La réunion convient cependant que l'OACI devrait travailler à la mise en activité de services de météorologie de l'espace pour l'aviation en élaborant des dispositions destinées à être insérées dans l'Annexe 3 en 2018 (dans le cadre du Bloc 1). Elle formule en conséquence la recommandation suivante :

Recommandation 2/7 — Élaboration de dispositions relatives à l'information sur les phénomènes météorologiques spatiaux

Il est recommandé qu'un groupe d'experts de l'OACI approprié, en étroite coordination avec l'OMM, élabore des dispositions relatives à la fourniture à la navigation aérienne internationale de de renseignements sur les phénomènes météorologiques spatiaux, en conformité avec le *Plan mondial de navigation aérienne* (Doc 9750), et qu'il soit également chargé de l'intégration de l'information ainsi produite dans le futur environnement de gestion globale de l'information (SWIM) sur lequel s'appuiera le futur système de gestion du trafic aérien interopérable à l'échelle mondiale, en traitant expressément :

a) des besoins en matière de services d'information de météorologie de l'espace, en accord avec le projet de concept d'opérations pour des services d'information de météorologie de l'espace ;

b) des critères de sélection et des capacités connexes pour la désignation de centres mondiaux et de centres régionaux de météorologie de l'espace, y compris le nombre optimal de ces centres ;

c) des dispositions appropriées en matière de gouvernance et de recouvrement des coûts pour la fourniture de services d'information de météorologie de l'espace, sur une base mondiale et régionale ;

d) des considérations relatives à l'utilisation des renseignements sur les phénomènes météorologiques spatiaux et aux diverses incidences que ces phénomènes pourraient avoir sur la navigation aérienne internationale.

Dégagements de matières radioactives dans l'atmosphère

2.2.10 La réunion constate les importants progrès réalisés depuis la réunion MET/02 en vue de l'insertion dans l'Annexe 3/Règlement technique [C3.1] de dispositions relatives à la diffusion de renseignements sur les dégagements de matières radioactives dans l'atmosphère et à la création d'une base de données mondiale destinée à aider le centre météorologique régional spécialisé (CMRS) de l'OMM, coïmplanté avec le VAAC de Londres (désigné comme point focal dans la notification directe aux centres de contrôle régional (ACC) concernés en cas de dégagement de matières radioactives. La réunion note aussi l'élaboration d'un concept d'opérations pour l'information sur les dégagements de matières radioactives dans l'atmosphère, concept qui devrait évoluer en accord avec le GANP, et note que cette information devrait être intégrée dans le futur environnement SWIM. Elle formule en conséquence la recommandation suivante :

Recommandation 2/8 — Poursuite de l'élaboration de dispositions relatives à l'information sur les dégagements de matières radioactives dans l'atmosphère

Il est recommandé qu'un groupe d'experts approprié de l'OACI, en étroite coordination avec l'OMM, poursuive l'élaboration de dispositions relatives à l'information sur les dégagements de matières radioactives dans l'atmosphère compte tenu du *Plan mondial de navigation aérienne* (Doc 9750), en évolution, y compris l'intégration de l'information ainsi produite dans le futur environnement de gestion globale de l'information (SWIM) sur lequel sera basé le futur système de gestion du trafic aérien interopérable à l'échelle mondiale.

Autres phénomènes météorologiques dangereux

2.2.11 La réunion se félicite des progrès considérables accomplis depuis la réunion MET/02, en particulier par le Groupe d'étude sur les avertissements météorologiques (METWSG), en vue de résoudre les problèmes persistants de mise en œuvre dans la fourniture de renseignements SIGMET par certains États, problèmes qui nuisent au maintien de la sécurité et de l'efficacité des vols. Elle estime que la mise en œuvre d'un système régional fournissant des avis sur certaines conditions météorologiques dangereuses, proposée par le METWSG, mérite d'être explorée activement afin de trouver une solution à long terme aux difficultés rencontrées à ce sujet.

2.2.12 La réunion souligne qu'en plus des défis techniques que pose l'établissement d'un tel système consultatif régional, il faudra résoudre un certain nombre de questions non techniques avant de procéder à quelque mise en œuvre que ce soit, notamment des questions d'arrangements de gouvernance et de recouvrement équitable des coûts. À ces fins, la réunion examine une évaluation stratégique des modalités de mise en œuvre d'un système régional d'avis de conditions météorologiques dangereuses ainsi qu'une évaluation des arrangements connexes de gouvernance et de recouvrement des coûts, comme prévu dans les Appendices D et E, respectivement. La réunion convient que le développement d'un tel système régional devrait évoluer en accord avec le GANP et que l'information produite dans le cadre du système envisagé devrait être intégrée dans le futur environnement SWIM.

2.2.13 La réunion note qu'il existe dans certains États des carences persistantes en matière de SIGMET et des exigences exprimées par les usagers de l'aviation pour une information harmonisée sur les conditions météorologiques dangereuses basée sur des phénomènes. À cet égard, il existe un besoin urgent, démontré par des usagers de l'aviation, d'établir des centres régionaux d'avis de conditions météorologiques dangereuses (RHWAC), pour aider les centres de veille météorologique (MWO) à fournir les renseignements SIGMET sur certaines conditions météorologiques dangereuses, comprenant au minimum les orages, le givrage, la turbulence et les ondes orographiques, mais non les cendres volcaniques et les cyclones tropicaux (pour lesquels il existe des systèmes consultatifs). La réunion convient qu'une phase initiale de communication d'avis à l'OMM servira de précurseur pour les deux phases suivantes du développement de la fourniture régionale d'avis de conditions météorologiques dangereuses, comme indiqué à l'Appendice D déjà mentionné.

2.2.14 Compte tenu des exigences des usagers, la réunion est entièrement d'accord sur le fait qu'un cadre régional pour les conditions météorologiques dangereuses devrait être mis en œuvre sans délai, tout en envisageant l'élaboration d'un cadre de gouvernance et de recouvrement des coûts.

2.2.15 La réunion reconnaît que l'élaboration d'un système régional d'avis de conditions météorologiques dangereuses devrait être soutenue par des éléments d'orientation appropriés à l'intention :

a) des groupes régionaux de planification et de mise en œuvre (PIRG) de l'OACI, indiquant le profil technique et les possibilités de centres météorologiques dans des États qui seraient capables de servir de RHWAC, compte tenu de considérations d'efficacité par rapport au coût, telles que l'utilisation de moyens existants ;

b) des États usagers et des États prestataires de services, sur les processus d'établissement et de diffusion des renseignements consultatifs, la coopération mutuelle, la viabilité de l'infrastructure météorologique existante et l'utilisation des compétences locales.

2.2.16 Compte tenu de ce qui précède, la réunion formule la recommandation suivante :

Recommandation 2/9 — Mise en œuvre d'un système consultatif régional sur certaines conditions météorologiques dangereuses en route

Il est recommandé qu'un groupe d'experts compétent de l'OACI, en étroite coordination avec l'OMM :

a) élabore avec diligence des dispositions appuyant la mise en œuvre d'un système régional d'avis basé sur phénomènes pour certaines conditions météorologiques dangereuses en route, compte tenu du *Plan mondial de navigation aérienne* (Doc 9750), en évolution, en tenant compte des exigences de longue date des usagers, en particulier dans les États où persistent des carences notables concernant les

SIGMET, en utilisant, selon qu'il convient, évaluations stratégique, de gouvernance et de recouvrement des coûts qui sont présentées en Appendices D et E ;

b) intègre l'information produite par le système en question ci-dessus dans le futur environnement de gestion globale de l'information sur lequel sera basé le futur système de gestion du trafic aérien interopérable à l'échelle mondiale ;

c) élabore des orientations appropriées pour appuyer les critères de sélection de centres régionaux d'avis de conditions météorologiques dangereuses, en tenant compte du rapport coût-efficacité, des processus d'établissement et de diffusion des renseignements consultatifs, de la coopération mutuelle, de la viabilité de l'infrastructure météorologique existante et de l'utilisation des compétences locales.

Note.— Les conditions météorologiques dangereuses visées comprennent au minimum les orages, le givrage, la turbulence et les ondes orographiques, mais non les cendres volcaniques et les cyclones tropicaux.

Assistance météorologique de région terminale

2.2.17 Sur un sujet connexe, la réunion examine une proposition visant à inclure une assistance météorologique de région terminale dans le Bloc 1 de la méthode ASBU. Elle prend note par ailleurs des travaux effectués dans un État en vue d'élaborer une information météorologique adaptée à l'ATM, qui mettent en évidence les incidences possibles des conditions météorologiques sur l'écoulement du trafic aérien et la nécessité d'élaborer des orientations sur une méthode de vérification en vue de l'amélioration continue de l'information météorologique pour l'ATM. La réunion convient qu'il serait important de faire expressément mention des exigences en matière de météorologie à l'appui de l'ATM en région terminale dans les modules du Bloc 1 de la méthode ASBU, notamment le module B1-AMET, notant qu'un tel ajout ne pourrait être fait que dans le cadre d'un examen périodique du GANP dans son ensemble. La réunion note qu'une étude pourrait être menée dans le cadre de projets pertinents de l'OMM sur le développement de l'assistance météorologique de région terminale, qui porteraient entre autres sur les incidences des conditions météorologiques à différents aéroports à travers le monde. La réunion reconnaît que l'expérience acquise grâce à de tels travaux serait assurément précieuse. Elle note en outre que d'autres études sont en cours pour déterminer les besoins des prestataires de services ATM et des exploitants en matière d'information météorologique en région terminale. Prenant note de ce débat, la réunion formule la recommandation suivante :

Recommandation 2/10 — Élaboration d'une assistance météorologique de région terminale

Il est recommandé que l'OACI, en étroite coordination avec l'OMM, soit chargée :

a) d'inclure une assistance météorologique pour les régions terminales et les autres exigences opérationnelles pertinentes dans le Bloc 1 et les blocs ultérieurs de la méthode de mise à niveau par blocs du système de l'aviation, pour mettre en évidence les incidences connexes possibles sur l'écoulement du trafic aérien, en considération du contrôle de la circulation aérienne et de la gestion du trafic aérien (ATM);

b) de mettre au point un service météorologique adapté à l'ATM pour les régions terminales, pour répondre aux besoins futurs de l'ATM identifiés par le *Plan mondial de navigation aérienne* (Doc 9750), et de refléter les besoins fonctionnels et de performance dans les dispositions pertinentes, en notant les résultats des travaux de groupes d'experts de l'OACI sur la météorologie, l'ATM et les opérations aériennes ;

c) d'élaborer des orientations sur une méthode de vérification en vue de l'amélioration continue de l'information météorologique pour l'ATM ;

d) d'intégrer l'information concernant le service météorologique pour la région terminale dans le futur environnement de gestion globale de l'information sur lequel sera basé le futur système ATM interopérable à l'échelle mondiale.

2.2.18 La réunion note avec satisfaction les importants progrès liés à l'établissement d'un centre d'assistance météorologique au trafic aérien de l'Office météorologique japonais, pour appuyer l'ATM. Elle note en particulier l'élaboration d'un nouveau système produisant une information météorologique adaptée qui pourrait servir à indiquer la probabilité d'incidences de conditions météorologiques sur l'écoulement du trafic aérien. Ce système pourrait à l'avenir fournir des indices pour mesurer l'ampleur des incidences des conditions météorologiques sur le système ATM.

2.2.19 De plus, la réunion prend connaissance d'une étude de cas illustrant comment la présence de cumulonimbus dans l'aire d'approche de l'aéroport international de Tokyo a fortement perturbé la circulation aérienne et comment le centre d'assistance météorologique au trafic aérien a aidé le centre ATM à assurer l'efficacité de l'ATM, soulignant ainsi l'importance de l'information sur les conditions météorologiques présentes dans les zones de contrôle d'approche.

Point 2 : Améliorer la sécurité et l'efficacité de la navigation aérienne internationale en renforçant la fourniture de l'assistance météorologique

2.3 : Information météorologique intégrée renforcée pour appuyer la prise de décisions opérationnelles stratégiques, pré-tactiques et tactiques à partir de 2028 (notamment le module ASBU B3-AMET)

2.3.1 Bien que le module B3-AMET de la méthode de mise à niveau par blocs du système de l'aviation (ASBU) figurant dans le *Plan mondial de navigation aérienne* (GANP) doive être mis en œuvre à partir de 2028, la réunion note que la complexité de la technologie dont il s'agit, en particulier les systèmes de gestion des vols et les communications par liaison de données, signifiait que les modifications potentiellement importantes à apporter aux systèmes et services existants ou devant être mis en place à court terme devaient être planifiées bien avant la période de mise en œuvre prévue pour le Bloc 3 (c.-à-d. 2028 et au-delà).

2.3.2 La réunion convient donc que les besoins techniques et les possibilités de service indiquées dans le Bloc 3 de l'ASBU, en particulier dans le module B3-AMET et les autres modules en rapport avec le SWIM, devront être pris en compte plusieurs années avant la date de mise en œuvre prévue de 2028. Elle formule en conséquence la recommandation suivante :

Recommandation 2/11 — Planification anticipée de la composante de météorologie aéronautique du Bloc 3 de l'ASBU

Il est recommandé qu'un groupe d'experts de l'OACI approprié soit chargé d'entreprendre au cours de la période de 2015 à 2020, en étroite collaboration avec l'OMM, la planification anticipée des besoins technologiques et des possibilités d'assistance météorologique aéronautique nécessaires afin d'appuyer la mise en œuvre pour 2028 du module B3-AMET de la méthode des mises à niveau par blocs du système de l'aviation (ASBU) et des composantes météorologiques des autres modules ASBU en rapport avec la gestion globale de l'information figurant dans le *Plan mondial de navigation aérienne* (Doc 9750).

2.3.3 La réunion examine les modifications qu'il est proposé d'apporter au système mondial de prévisions de zone (SMPZ) dans la période du Bloc 3, qui devront être focalisées sur les principes énoncés dans l'Appendice F. Ayant terminé son examen, et reconnaissant qu'envisager pleinement l'état futur du système de l'aviation (et de la composante SMPZ) à l'échéance de 2028 est un défi particulièrement grand, la réunion est d'accord sur les principes à utiliser comme base pour de futurs développements du SMPZ à l'appui du module B3-AMET de la méthode ASBU. Elle formule en conséquence la recommandation suivante :

Recommandation 2/12 — Développement du SMPZ à l'appui des mises à niveau par blocs du système de l'aviation (ASBU) au-delà de 2028

Il est recommandé que l'OACI utilise les principes indiqués par les livrables pour les opérations en route inclus dans l'Appendice F comme base pour le développement futur du système mondial de prévisions de zone (SMPZ) à l'appui du module B3-AMET de la méthode ASBU.

Point 2 : Améliorer la sécurité et l'efficacité de la navigation aérienne internationale en renforçant la fourniture de l'assistance météorologique

2.4 : Prise de décisions en collaboration et conscience commune de la situation — considérations relatives à l'automatisation et aux facteurs humains

2.4.1 La réunion note les avantages attendus de l'application de la prise de décisions en collaboration (CDM) dans un environnement d'exploitation riche en informations. La CDM est considérée comme un aspect fondamental de la façon dont le système de gestion mondiale du trafic aérien (ATM) atteindra la maturité, garantissant que les décisions prises sont des décisions informées, comprises par tous et fondées sur une évaluation partagée des renseignements sur lesquels elles reposent. Il est noté que comme les renseignements météorologiques aéronautiques font partie intégrante de l'information disponible totale à partir de laquelle les décisions opérationnelles seront prises de manière collaborative par la collectivité ATM, il s'ensuit que la météorologie aéronautique sera un élément habilitant clé de la conscience commune de la situation.

2.4.2 La réunion souligne que dans un tel environnement collaboratif, une gouvernance sera de toute évidence nécessaire, de même qu'une gestion de la qualité et une normalisation des données pour lesquelles il existe des formes de présentation prescrites qui sont communes à tous les domaines d'information dans le cadre du futur environnement de gestion globale de l'information (SWIM) de l'ATM mondiale.

2.4.3 La réunion note que la transition prévue de la fourniture de services axés sur des produits à la fourniture de services axés sur l'information ou des données signifie inévitablement qu'il y aura moins d'interaction avec les renseignements météorologiques aéronautiques (par les prestataires et les utilisateurs) en raison de l'automatisation accrue. De plus, étant donné un tel environnement d'exploitation automatisé, et conscient du caractère unique des décisions opérationnelles des usagers, la réunion convient qu'il serait souhaitable de ne pas être prescriptif en ce qui concerne les normes de visualisation de l'information météorologique aéronautique communément disponible, car les besoins et capacités opérationnels de chaque usager seront la plupart du temps uniques.

2.4.4 La réunion note qu'afin de maximiser l'interopérabilité et de faciliter le processus de mise en œuvre, les prestataires de services de navigation aérienne (ANSP), en tant que membres clés de la collectivité ATM, joueront un rôle à part entière dans la transition des collectivités de météorologie aéronautique et ATM vers un environnement axé sur l'information.

2.4.5 La réunion convient que la transition à un environnement d'exploitation plus collaboratif et à une automatisation accrue exigera de modifier la façon dont les renseignements météorologiques aéronautiques sont mis à la disposition des usagers et utilisés par eux, et que la gouvernance est un prérequis. De plus, il est nécessaire de veiller à ce que les considérations relatives aux facteurs humains continuent de faire partie intégrante de l'assistance météorologique aéronautique pendant et après la transition. Compte tenu de ce qui précède, la réunion formule les recommandations suivantes :

Recommandation 2/13 — Élaboration de dispositions relatives aux services d'information de météorologie aéronautique dans le contexte de la CDM et de la conscience commune de la situation

Il est recommandé que l'OACI et l'OMM veillent à l'élaboration de dispositions relatives à des services d'information de météorologie aéronautique qui encouragent la prise de décisions en collaboration (CDM) et favorisent la conscience commune de la situation au sein de la collectivité ATM.

Recommandation 2/14 — Prise en compte des considérations relatives aux facteurs humains dans l'élaboration des dispositions relatives à l'assistance météorologique aéronautique

Il est recommandé que l'OACI et l'OMM veillent à ce que les considérations relatives aux facteurs humains occupent une place centrale dans l'élaboration des services d'information de météorologie aéronautique

2.5 Déclaration des délégations de la Chine et de la Fédération de Russie

Système mondial de prévisions de zone (SMPZ)

2.5.1 Le développement du SMPZ devrait être mis dans son contexte historique propre. Il est entendu que la mise en place du SMPZ en 1982 était fondée sur la situation du moment, à savoir que les États ne disposaient pas tous de moyens de prévision numérique du temps (NWP) et de diffusion par satellite. Toutefois, au cours des trois dernières décennies, la situation mondiale a radicalement changé : de nombreux États exploitent actuellement des modèles de PNT qui ont des échelles spatiales et temporelles élevées, allant jusqu'à une semaine ou davantage. Dans le même temps, les technologies de diffusion par satellite ne sont plus économiques par rapport à l'Internet. Par conséquent, à part les prévisions du modèle SMPZ, il existe de nombreux autres modèles mondiaux de prévision qui pourraient être disponibles aux fins de la planification des vols en route, à condition qu'ils satisfassent à un niveau requis de performance et qu'ils soient désignés à l'échelle internationale.

2.5.2 Avec la croissance considérable du trafic aérien dans le monde, et en particulier dans la région Asie-Pacifique, il y a du côté des utilisateurs une demande croissante de meilleures prévisions et d'amendements plus opportuns des renseignements SIGWX afin de répondre aux changements rapides des conditions météorologiques, par exemple une convection importante qui n'avait pas été prévue par les centres mondiaux existants. En outre, dans le futur environnement SWIM où il y aura une dépendance accrue aux prévisions aux points de grille pour appuyer l'ATM et la TBO, on ne peut établir avec certitude que la structure SMPZ actuelle répondra aux besoins futurs des utilisateurs. Pour appuyer la croissance inévitable du trafic aérien, les centres doivent étudier les demandes croissantes venant des utilisateurs, auxquelles l'arrangement actuel, dans lequel on ne dispose que de deux centres mondiaux, pourrait ne pas répondre au mieux. Il est jugé réalisable de réétudier la place et le rôle du SMPZ dans le nouveau contexte du GANP et de la méthode ASBU. Dans ce contexte, lors de l'examen des centres mondiaux, les aspects performance, équité et durabilité et notamment les arrangements de ce cours devraient être pris en compte. Les utilisateurs devraient avoir le choix du modèle mondial qui répond au mieux à leurs besoins opérationnels.

2.5.3 De plus, l'Annexe 3 et les futures PANS-MET devraient réglementer la prestation de l'assistance météorologique, et notamment les prévisions SMPZ, c'est-à-dire déterminer les normes de performance requises auxquelles chaque service devrait satisfaire, et non les organismes qui fournissent le service.

2.6 Déclaration des délégations de Bahreïn, des Émirats arabes unis, du Koweït et du Qatar

À l'intention du Secrétaire général de l'OACI et de l'OMM

2.6.1 Nous nous référons à l'appui qu'apporte la Réunion météorologie (MET) à l'échelon division (2014) de l'OACI d'une part au concept de « Ciel unique » dans le cadre du *Plan mondial de navigation aérienne* (GANP) et d'autre part à la composante MET de la méthode de mise à niveau par blocs du système de l'aviation (ASBU). Les représentants de la sous-région à la Réunion météorologie (MET) à l'échelon division (2014) de l'OACI (Bahreïn, Émirats arabes unis, Koweït et Qatar) souhaitent soumettre à votre examen les préoccupations exposées ci-après.

2.6.1.1 S'agissant du projet de recommandation figurant au paragraphe 2.5.6 de la note MET/14-WP/6-CAeM-15/Doc.6, sur la mise en œuvre d'un système consultatif régional pour certaines conditions météorologiques dangereuses en route, ainsi que des Appendices B et C, nous souhaitons appeler votre attention sur le fait que la mise en œuvre d'un tel système pour diffuser les renseignements SIGMET aura une incidence sur :

a) le rôle de la sous-région en tant que prestataire émettant des avertissements SIGMET, et la viabilité organisationnelle des SMHN de la sous-région ;

b) l'exactitude et la compétence avec lesquelles la sous-région émet des avertissements SIGMET depuis 1960, en pleine conformité avec les règles ;

c) les investissements actuels et permanents dans les ressources humaines et les systèmes météorologiques ;

d) la perception de frais annuels (paragraphes 5.2.1.3 et 5.2.1.4 de l'Appendice C de la note MET/14-WP/6-CAeM-15/Doc.6).

2.6.2 En conclusion, les pays susmentionnés demandent à l'OACI et à l'OMM d'examiner les recommandations proposées ci-dessus par la sous-région, car elles auront des incidences sur le rôle directeur des prestataires régionaux uniques envers un système international contrôlé. Depuis plus d'une décennie, les pays membres en question fournissent tous des services météorologiques utiles, de qualité et efficients à la collectivité aéronautique, sous forme d'alertes rapides face aux risques météorologiques. Notre sous-région a investi dans des systèmes météorologiques pour fournir un service SIGMET dans les FIR qui lui ont été assignées, et elle a des plans d'investissement en cours en vue de la contribution à la mosaïque radar composite, de la fourniture de PNT à haute résolution dans les domaines atmosphérique et océanique, ainsi que de la réception de données satellite et de leur rediffusion à l'échelon sous-régional. Après tous ces investissements, nous risquons de ne plus pouvoir maintenir et soutenir ces infrastructures dans le cadre du nouvel environnement SWIM régionalisé, et de nous retrouver dans une situation où nous perdrons peut-être notre rôle visible parmi les autres membres ainsi que le soutien du gouvernement.

2.6.3 Outre les circonstances propres à notre région, nous demandons à l'OACI et à l'OMM de clarifier les règlements (en ce qui concerne les accords bilatéraux) et les règles à mettre en place avant et après l'attribution de la responsabilité de la prestation du service SIGMET régional.

– – – – – – – – – – – –

APPENDICE A

LIVRABLES DU SYSTÈME MONDIAL DE PRÉVISIONS DE ZONE (SMPZ) À L'APPUI DU BLOC ASBU 0

— Mettre en œuvre des algorithmes améliorés pour les prévisions de turbulence, ce qui comprend de remplacer la « possibilité de turbulence » par l'« intensité de la turbulence » [p. ex., taux de dissipation des tourbillons (EDR)]

— Mettre en œuvre des algorithmes améliorés pour les prévisions de givrage, ce qui comprend de remplacer la « possibilité de givrage » par l'« intensité du givrage »

— Vérification régionale et mondiale des prévisions du SMPZ en utilisant les données fournies par les États et les organisations utilisatrices.

— — — — — — — — — — — —

APPENDICE B

LIVRABLES DU SYSTÈME MONDIAL DE PRÉVISIONS DE ZONE À L'APPUI DES BLOCS ASBU 1 ET 2

Les modifications qu'il est prévu d'apporter pendant la période du module B1-AMET — *Renseignements météorologiques appuyant un renforcement de l'efficacité et de la sécurité opérationnelles* (2018-2028) sont les suivantes :

- 2018-2023 :
  - Mise en œuvre d'un système de prévision d'ensemble pour les cumulonimbus
  - Mise en œuvre de prévisions du type de turbulence (p. ex. convection, cisaillement de courant-jet, relief) utilisant le taux de dissipation des tourbillons (EDR)
  - Mise en œuvre d'une grille de résolution plus fine pour les données du SMPZ
  - Mise en œuvre de prévisions probabilistes étalonnées pour le givrage, la turbulence et les cumulonimbus
  - Fourniture d'un ensemble partiel de données d'information météorologique se prêtant à une intégration dans les systèmes d'aide à la décision en matière de planification de vol, de gestion de vol et de gestion du trafic aérien (ATM) pour le temps en route
  - Mise en œuvre de prévisions du temps significatif (SIGWX) au format XML/GML comme moyen de remplacement des prévisions SIGWX établies dans la forme symbolique du code BUFR
  - Mise à disposition des données du SMPZ au moyen du système de gestion globale de l'information (SWIM)
- 2023-2028 :
  - Fourniture d'un ensemble enrichi de données d'information météorologique se prêtant à une intégration dans les systèmes d'aide à la décision en matière de planification de vol, de gestion de vol et de gestion du trafic aérien (ATM) pour le temps en route

Algorithmes améliorés

Les améliorations par les CMPZ comprennent entre autres les suivantes :

- Cumulonimbus :
  - Améliorations liées au schéma de convection et à l'utilisation de prévisions d'ensemble
  - Modification des paramètres de sortie pour fournir des valeurs étalonnées plus utiles

- Turbulence :

  - Indication du type de turbulence (turbulence due à la convection, à un cisaillement du vent dans les hautes couches ou au relief)

  - Sortie probabiliste étalonnée utilisant l'EDR

- Givrage :
  - Sortie probabiliste étalonnée

— — — — — — — — — — — —

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 *Meteorological Information Supporting Enhanced Operational Efficiency and Safety* 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

Contents

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 B*1-AMET* and B*3-AMET*, time frames 2018 and 2028 respectively[1].

Module B*0-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 B*0-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 B*1-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 (SO_2), thus these observation and forecasts do not exist. However, Grímsvötn (2011) highlighted shortfalls in our understanding of and service provision for possible SO_2 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 VAAC[4] 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 IAVWOPSG[5].

---

[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 only[6]. 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.

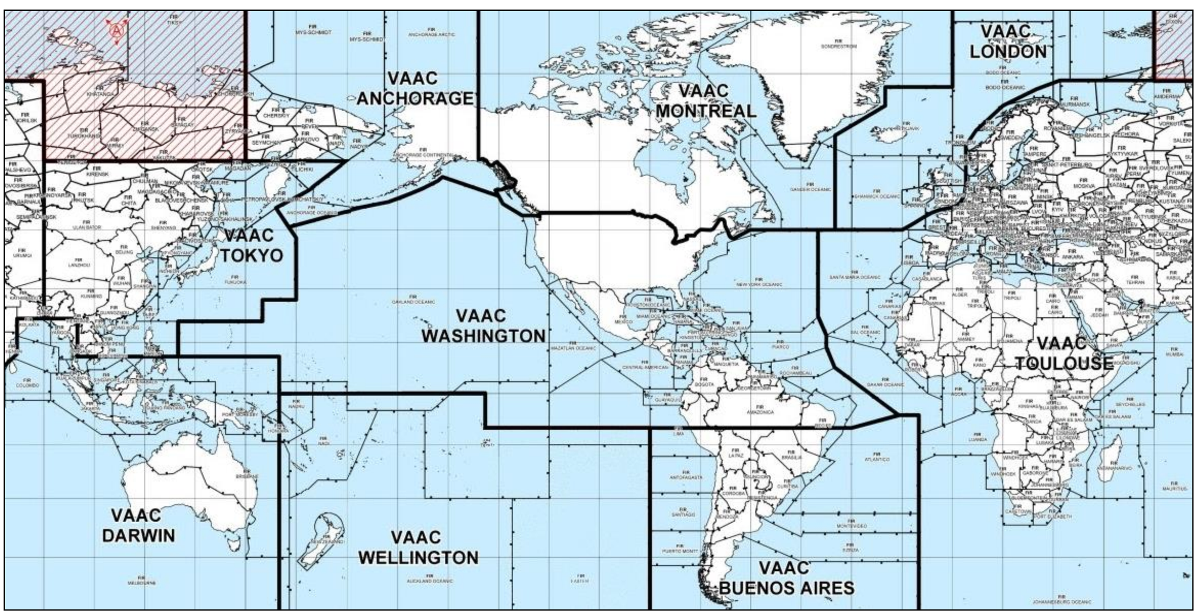


Figure 1. **Areas of responsibility for the nine VAACs.**

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 VONA[7]. 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 ASHTAM[8], 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.

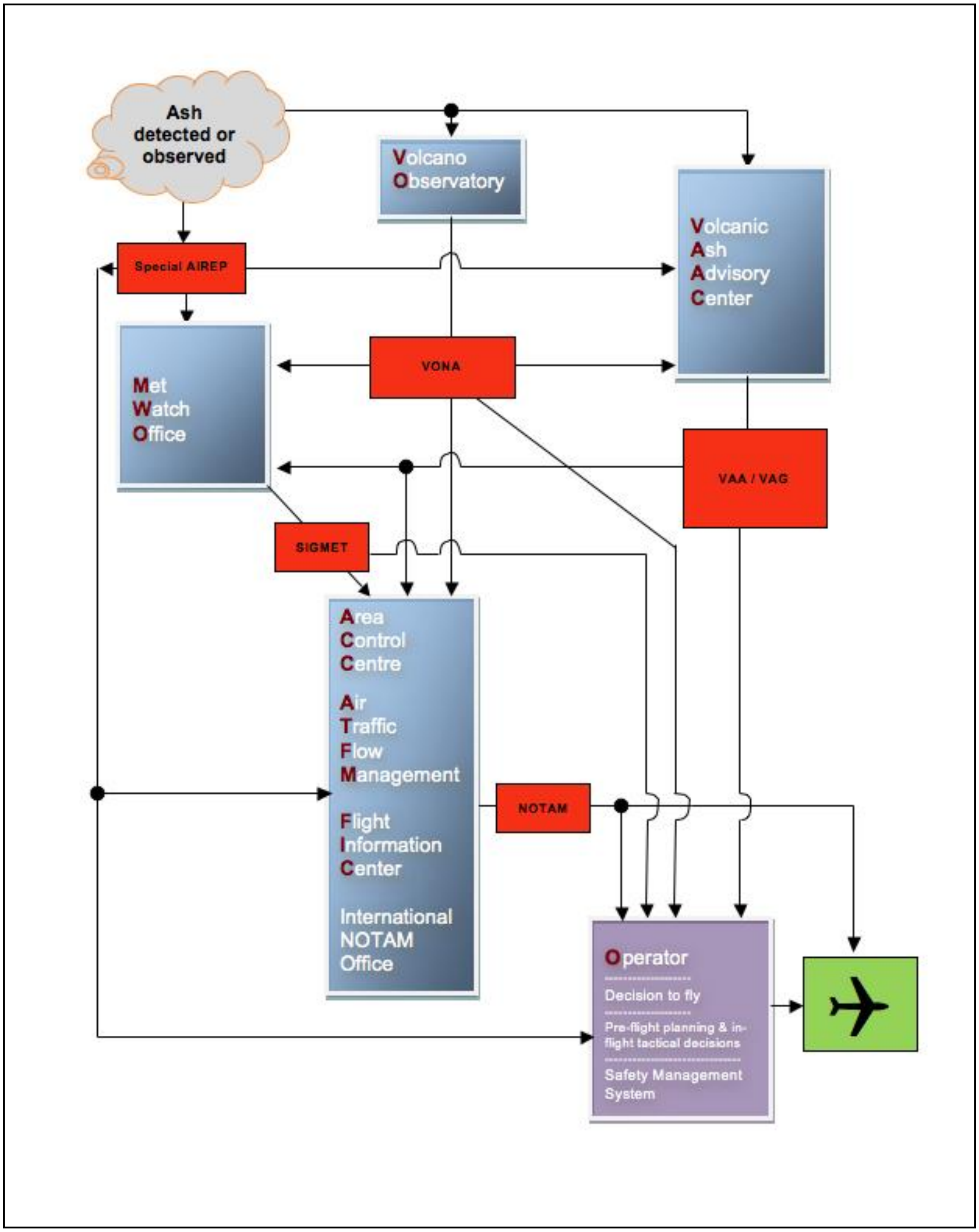


Figure 2. High-level information flow diagram between the users and providers of contemporary volcanic ash cloud information. The lines represent the distribution of information over aeronautical fixed services, with the exception of the VONA. The box colors do not represent significance; rather they 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	
Service Provider		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
MET Service Provider	Aerodrome Met Office and Stations	Report pre-eruption activity	Report	Report		METAR/SPECI. Aerodrome Warning
MET Service Provider	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
MET Service Provider	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	
Service Provider		Pre-Eruption	Eruption[9]	Volcanic Ash[10]	Information Received and Used	Information Provided (shared)
	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 B*0-AMET* of the ASBUs is the baseline services for Block 0. The following is taken from ASBU module B*0-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 cloud*[13]*, 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 B*1-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 B*1-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 B*1-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 B*3-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 B*0-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 proposed[14] 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 B*1-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 B*1-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 B*3-AMET* (*Enhanced Operational Decisions through Integrated Meteorological Information)* are:

- Develop other volcanic derived contaminant forecasts, specifically SO_2
- 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 SO_2, 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, SO_2 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 SO_2 has never been a significant immediate safety hazard to an aircraft or health hazard to its occupants.

Through the work of the IVATF and IAVWOPSG[15], 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 SO_2 in the atmosphere that would be observed or forecast) that, after passing through the aircrafts 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 B*3-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 SO_2
- 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 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:

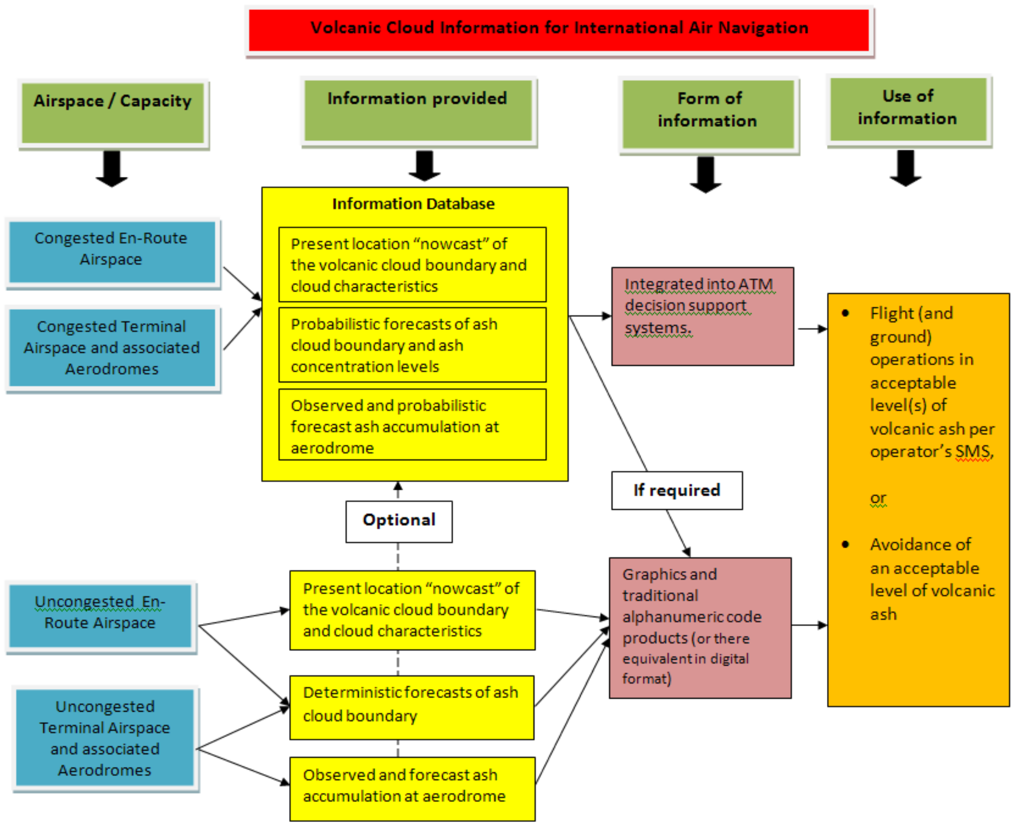
- The development of certifiable volcanic ash tolerances may take many years, or may not be feasible or beneficial to operators (if by 2028 the development is not possible then further work will be done to improve the avoidance of ash)
- Some States may not accept the VAA as equivalent to the SIGMET 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 needs[16] 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	X
	SO2	X	X	X	X	X	X
	Electro-magnetic risks to avionics	X	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		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
contamination level						
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 system[18].

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 capacity[19] 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 area[20]. 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 defined[21] 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 **<u>Phase One</u> (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.

<u>Explanatory note</u>: *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 **<u>Phase Two</u> (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

[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.

amalgamation of existing volcanic ash advisory 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 RHWC 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 otherwise[23], of consolidating, in a further phase (potentially a Phase Four), hazardous meteorological condition information issued from a few centres conjointly covering the globe[24], 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.

[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.

In years 2014, 2015 and 2016 the number of strategic objectives of ICAO will increase to five. Ten key air navigation policy principles[25] 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

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 environment[26] 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

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

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

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 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 information[27] including special air-reports to the regional

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

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 regional hazardous weather advisory centres and eventually the regional hazardous weather centre products with formal routine and special feedback to the centres[28];

(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.

— — — — — — — —

[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 capacity[30] 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 area[31]. 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 principles[32] 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 centres[33]. Operationally meeting this requirement, let alone the cost, may well be above and beyond what the provider State would be 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. Consider:

(a) IATA has 240 members comprising 84% of the total air traffic and provides the international electronic ticketing systems. IATA has real-time data on flights, origin, destination, route, passenger number and freight Very significant levels electronic funds flow through the system[34].

Inferred from ICAO data[35] and for the three ICAO Regions currently under consideration for implementation of RHWACs, there were about six million aircraft movements in 2010. Using a crude estimation with an average of say 150 passengers per flight, this translates to nearly one billion passengers. A simple calculation would suggest that an IATA levy of around one cent (US$) would yield around US$10 million per year to fund the three RHWACs.

With activity growth expected to double by 2030, it could be expected that any IATA levy for the purpose would decrease over time.

The very significant difference in this third party/IATA approach is that it is not reliant on State acquiescence, legislation change, or basic contributory co-operation. The system could be established entirely by the two organizations with pre-set and annually adjusted funding going direct to the RHWACs.

(b) 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

[34] Refer IATA Annual Review 2013
[35] Global Air Transport outlook to 2030 and Trends to 2040 (Cir 333, AT/190)

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.

— — — — — — — —

APPENDIX F

WORLD AREA FORECAST SYSTEM DELIVERABLES IN SUPPORT OF ASBU BLOCK 3

- Fully integrated multi-member ensemble hazard forecasts
    - Implementation of the WAFS-database, populated with meteorological information from appropriate models to produce ensemble forecasts of global meteorological information
- Implementation of high spatial and temporal resolution models resulting in improved representations of meteorological information
- Provide full dataset of meteorological information suitable for integration into flight planning for en-route operations, flight management and air traffic management (ATM) decision support systems
- Fully automated gridded and significant weather forecast (SIGWX) output
- Full implementation of system wide information management (SWIM) for access to WAFS data
- Retirement of legacy WAFS products and dissemination systems

— END —