INTERNATIONAL CIVIL AVIATION ORGANIZATION

VOLCANIC ASH CONTINGENCY PLAN

AFI REGION

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UNDER THE AUTHORITY OF THE APIRG

FOREWARD

Within and adjacent to the Africa and Indian Ocean (AFI) Region there are areas of volcanic activities which are likely to affect flight in the AFI Region. The major volcanoes in the region are located in the following States: Algeria, Cameroon, Cape Verde Islands, Chad, Comoros Island, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, France (Reunion Island), Kenya, Madagascar, Mali, Niger, Nigeria, Rwanda, Sao Tome and Principe, Spain (Canary Islands, Madeira), Sudan, Tanzania and Uganda. The names of the concerned volcano are listed in **APPENDIX K** (source: Smithsonian Institution).

This document is the AFI Air Traffic Management (ATM) Volcanic Ash Contingency Plan which sets out standardised guidelines and procedures for the provision of information to airlines and en-route aircraft before and during a volcanic eruption. Volcanic contamination, of which volcanic ash is the most serious, is a hazard for safe flight operations. Mitigating the hazards posed by volcanic ash in the atmosphere and/or at the aerodrome cannot be resolved in isolation but through collaborative decision-making (CDM) involving all stakeholders concerned. During an eruption volcanic contamination can reach and exceed the cruising altitudes of turbine-powered aircraft within minutes and spread over vast geographical areas within a few days. Encounters with volcanic ash may result in a variety of hazards including one or more of the following:

a) the malfunction, or failure, of one or more engines leading not only to reduction, or complete loss, of thrust but also to failures of electrical, pneumatic and hydraulic systems;

b) the blockage of pilot and static sensors resulting in unreliable airspeed indications and erroneous warnings;

c) windscreens rendered partially or completely opaque;

d) smoke, dust and/or toxic chemical contamination of cabin air requiring crew to don oxygen masks, thus impacting communications; electronic systems may also be affected;

e) the erosion of external and internal aircraft components;

f) reduced electronic cooling efficiency leading to a wide range of aircraft system failures;

g) the aircraft may have to be manoeuvred in a manner that conflicts with other aircraft; and

h) Volcanic ash deposition on a runway may degrade aircraft braking performance, most significantly if the volcanic ash is wet; and in extreme cases, this can lead to runway closure.

Operators are required by ICAO Annex 6 – *Operation of Aircraft* to implement appropriate mitigation measures for volcanic ash in accordance with their safety management system (SMS) as approved by the State of the Operator/Registry. The guidelines provided in this document assume that the ICAO requirements regarding safety management systems have been implemented by the operators. Detailed guidance on Safety Risk Assessments (SRAs) for flight operations with regard to volcanic contamination can be found in the manual on Flight Safety and Volcanic Ash – Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination (ICAO Doc 9974).

This document is an ATM contingency plan including its interfaces with supporting services such as Aeronautical Information Service (AIS) and Meteorological (MET) services and that the plan therefore primarily addresses the provider States. Distribution of applicable AIS and MET messages related to volcanic ash are set out in relevant ICAO Annexes– namely *Annex 15– Aeronautical Information Services and Annex 3 – Meteorological Service for International Air Navigation.* .

Volcanic Ash can also affect the operation of aircraft at aerodromes. Volcanic ash deposition at an aerodrome, even in very small amounts, can result in the closure of the aerodrome until all the deposited ash has been removed. In extreme cases, the aerodrome may no longer be available for operation at all, resulting in repercussions on the ATM system; e.g. diversions, revised traffic flow, etc.

Some aircraft types or engine technologies are more vulnerable to volcanic contaminants than others; therefore any specific mitigation measures to be applied would have to take into account these variances. Considering that a commercial aircraft will travel about 150 km (80 NM) in 10 minutes and that volcanic ash can rise to flight levels

commonly used by turbine-engine aeroplanes in half that time, a timely response to volcanic eruptions and volcanic ash in the atmosphere is essential.

It is imperative that information on the volcanic activity is disseminated as soon as possible. In order to assist staff in expediting the process of originating and issuing relevant AIS and MET messages (VA SIGMET, NOTAM, and ASHTAM), a series of templates should be available for different stages of the volcanic activity. A list of ICAO registered volcanoes — see the Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds (ICAO Doc 9691) Appendix F — should be available at the international NOTAM office with volcano name, number and nominal position. In order to ensure the smooth implementation and effectiveness of the contingency plan in case of an actual volcanic eruption, annual AFI ATM/MET Task Force Volcanic Ash Exercises (VAEX/AFI) should be conducted.

This document has been prepared, and is in line with a proposal for amendment to the Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM, Doc 4444) paragraph 15.8 Procedures for an ATC unit when a volcanic ash cloud is reported or forecast — which is expected to become applicable in November 2014.

General considerations during the development of an ATM contingency plan for volcanic ash and anticipated flight crew issues when encountering volcanic ash are provided in Appendices A and B respectively.

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1. TERMINOLOGY

1.1 Areas of Contamination

1.1.1 Information on areas of observed and/or forecast volcanic ash in the atmosphere is provided by means of appropriate MET messages in accordance with the *Meteorological Service for International Air Navigation* (Annex 3).

1.2 Danger Areas

1.2.1 If it is considered that the volcanic event could pose a hazard to aviation, a danger area3 may be declared by NOTAM; however, this option should only be applied over and in the proximity of the volcanic source. Normally, clearances will not be issued through the danger area unless explicitly requested by the flight crew. In this context it should be noted that the final responsibility for aircraft safety rests with the flight crew. Therefore, the final decision regarding route, whether it will be to avoid or proceed through an area of volcanic activity, is the flight crew's responsibility. Wherever this document discusses the possible establishment of danger areas, States are not prevented from establishing restricted or prohibited areas over the sovereign territory of the State if considered necessary by the State concerned.

1.2.2. Although it is the prerogative of the provider State to promulgate a danger area in airspace over the high seas, it should be recognized that restrictions to the freedom of flight over the high seas cannot be imposed in accordance with the United Nations Convention on the Law of the Sea (Montego Bay 1982).

1.3 Phases of an Event

1.3.1 The response to a volcanic event that affects air traffic has been divided into four distinct phases in this document - Pre-Eruption Phase, a Start of Eruption Phase, an On-going Eruption Phase, and a Recovery Phase- as follows:

a) **PRE-ERUPTION PHASE** (when applicable)**:** The initial response, "raising the alert", commences when a volcanic eruption is expected.

   1) Appropriate AIS (NOTAM) and MET (VA SIGMET) messages may be issued in accordance with Annex 15 and Annex 3 respectively, and disseminated to affected aircraft in flight by the most expeditious means. It should be noted that, sometimes volcanoes erupt unexpectedly without any alert being raised, hence the pre-eruption phase may be omitted.

b) **START OF ERUPTION PHASE** (when applicable): The start of eruption phase commences at the outbreak of the volcanic eruption and entrance of the volcanic ash into the atmosphere and mainly pertains to aircraft in flight. Appropriate AIS (NOTAM:ASHTAM) and MET (VA SIGMET) messages may be issued as appropriate in accordance with Annex 15 and Annex 3 respectively, and a danger area may be declared by NOTAM. Normally, clearances will not be issued through the danger area unless explicitly requested by the flight crew.

c) **ONGOING ERUPTION PHASE:** The ongoing eruption phase commences with the issuance of the first volcanic ash advisory (VAA) containing information on the extent and movement of the volcanic ash cloud following completion of the previous reactive responses. Appropriate AIS (NOTAM:ASHTAM) and MET (VA SIGMET) messages may be issued as appropriate in accordance with Annex 15 and Annex 3 respectively.

d) **RECOVERY PHASE:** The recovery phase commences with the issuance of the first VAA containing a statement that "NO VA EXP" (i.e. "No Volcanic Ash Expected) which normally occurs when it is determined that no volcanic activity has reverted to its pre-eruption state.

Note: These descriptions are amplified in Chapter 3 of this document.

1.3.2. Although the four distinct phases herein describe actions to be undertaken during an actual volcanic event, they are based on a theoretical scenario. Actual eruptions may not always be distinct with respect to ATM actions to be undertaken. Similarly, an eruption may occur without any pre-eruptive activity, or may cease and restart more than once. Hence, the first observation may be the presence of an ash cloud which is already some distance away from the volcano. It is essential that the contingency planning prepares the ATM system for an appropriate response depending on the actual conditions. Therefore, the "Pre-Eruption Phase" and "Start of Eruption Phase" described in this document are annotated "when applicable" in order to provide for flexibility in the application of the contingency plan in those parts of the world with insufficient volcano monitoring and alerting.

1.3.3 Flight crews are required to report observations of significant volcanic activity by means of a Special Air Report (AIREP). Arrangements should be put in place to ensure that such information is transferred without delay to the appropriate aeronautical institutions responsible for subsequent action. Reports (text to be included referring to **APPENDIX C**).

2. PRE-ERUPTION PHASE

2.1 General

2.1.1 Where flight operations are planned in areas that are susceptible to volcanic eruptions, ATS units may expect to receive from flight crews the ICAO Volcanic Activity Report (VAR) form (published in the *Procedures for Air Navigation Services – Air Traffic Management* (PANS-ATM, Doc 4444) Appendix 1).

2.1.2 The focus of this phase is to gain early recognition of volcanic events. This phase is frequently characterised by a limited availability of information on the potential extent and severity of the impending eruption. The priority is to ensure the continued safety of aircraft in flight, and there is therefore a requirement to promulgate information as a matter of urgency. Notwithstanding the potentially limited extent of information available, the pre-eruption phase actions described below should be carried out for every expected eruption..

2.1.3 The initial response, "raising the alert", commences when a volcanic eruption is expected. Initial awareness of the event may be by means of an AIREP/VAR and/or from information provided by meteorological or volcanological agencies. Arrangements in each State between designated volcano observatories, meteorological and air traffic management agencies shouldensure that alerting information is provided expeditiously by the most appropriate means (VA SIGMET, NOTAM or ASHTAM or re-transmitted AIREPs,) to provide continued safety of flight.

2.1.4 Emphasis is placed on raising awareness of the hazard and to protect aircraft in flight. The actions are based on well-prepared, well-exercised contingency plans and standard operating procedures. Aircraft are expected to clear or avoid the volcanic ash affected area based on standard operating procedures.

2.2 Originating Area Control Centre (ACC) Actions (eruption in its own flight information region (FIR))

2.2.1 In the event of significant pre-eruption volcanic activity, which could pose a hazard to aviation, an area control centre (ACC)[1], on receiving information of such an occurrence, should carry out the following:

a) ensure that appropriate AIS messages are originated in accordance with Annex 15. These must provide as precise information as is available regarding the activity of the volcano. It is imperative that this information is issued by the international NOTAM office and disseminated as soon as possible in accordance with the provisions of Annex 15;;

b) when so required by the State, define an initial, precautionary danger area in accordance with established procedures. The size of the danger area should encompass a volume of airspace in accordance with the information available, aiming to avoid undue disruption of flight operations;;

i) if no such procedures have been established, the danger area should be defined as a circle with a radius of xxx km (xx NM)[2]. The circle should be centred on the estimated or known location of the volcanic activity;

ii) although ATC would not normally initiate a clearance through a danger area, it will inform aircraft about the potential hazard and continue to provide normal services. It is the responsibility of the pilot-in-command to determine the safest course of action.

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c) advise the associated Meteorological Watch Office (MWO) and the appropriate VAAC (unless the initial notification originated from such provider(s)), who will then inform the appropriate air traffic flow management (ATFM) units;.

d) alert flights already within the area concerned and offer assistance to enable aircraft to exit the area in the most expeditious and appropriate manner. Flight crews should be provided with all necessary information required to make safe and efficient decisions in dealing with the hazards in the defined area. Flights which would be expected to penetrate the area should be re-cleared onto routes that will keep them clear; and

e) immediately notify other affected ACCs of the event and the location and dimensions of the area concerned. The ACCshould also negotiate any re-routings necessary for flights already coordinated but still within adjacent flight information regions (FIRs). and provide any information on potential implications on traffic flow and its capability to handle the expected traffic. It is also expected that adjacent ACCs will be asked to reroute flights not yet coordinated to keep them clear of the area. It should be noted that flight crews may make the decision not to completely avoid the area based on, for example, visual observations.

f) implement flow management measures if necessary to maintain the required level of safety.

Note 1. — In order to assist staff in expediting the process of composing the AIS messages, a series of templates should be available for this stage of the volcanic activity.

2.2.2 In addition to sending the relevant AIS messages to the normal distribution list, it will be sent to the relevant meteorological facilities, for example, agencies with the appropriate World Meteorological Organisation (WMO) header.

2.3 Adjacent ACC Actions

2.3.1 During the pre-eruption phase ATC will not normally initiate clearances through a danger area; however, it will inform aircraft about the potential hazard and continue to provide normal services. Any ash contamination should be contained within a limited area and disruption to traffic should not be excessive. Adjacent ACCs should take the following action to assist:

a) when advised, re-clear flights to which services are being provided and which will be affected by the danger area; and

b) unless otherwise instructed, continue normal operations and:

i) if one or more routes are affected by the area, suggest re-routings to the affected aircraft onto routes clear of the danger area; and

ii) maintain awareness of the affected area.

[2] The size of the area to be agreed in the region concerned.

2.4. ATFM Unit Actions (where established)

2.4.1 The ATFM unit and the associated volcanic ash advisory centre (VAAC) will determine how their initial communications will take place on the basis of bilateral agreements. Upon reception of preliminary information on volcanic activity from the lead VAAC, the ATFM unit should initiate actions in accordance with its procedures to ensure exchange of information in order to support CDM between air navigation service providers (ANSPs), meteorological watch offices (MWOs), VAACs and aircraft operators concerned.

3. START OF ERUPTION PHASE

3.1 General

3.1.1 This phase commences at the outbreak of volcanic eruption with volcanic ash being ejected into the atmosphere. , The focus of the processes in this phase is to protect aircraft in flight and at aerodromes from the hazards of the eruption through the collection and use of relevant information..

3.1.2 In addition to relevant actions described under the pre-eruption phase, major activities of the start of eruption phase are: Issuance of an eruption commenced VA SIGMET; eruption commenced NOTAM/ASHTAM; as well as provision of information and assistance to airborne traffic.. As appropriate, danger areas will be declared via NOTAM. This phase will last until such time as the on-going eruption phase can be activated.

3.2 Originating ACC Actions (*eruption in its own FIR*)

3.2.1 The ACC providing services in the FIR within which the volcanic eruption takes place should inform flights about the existence, extent and forecast movement of volcanic ash and provide information useful for the safe and efficient conduct of flights.

3.2.2 If necessary, rerouting of traffic should commence immediately or may be in progress if the alerting time has been sufficient to facilitate activation of the pre-eruption phase. The ACC should assist in rerouting aircraft around the danger area as expeditiously as possible. Adjacent ACCs should also take the danger area into account and give similar assistance to aircraft as early as possible.

3.2.3 During the start of eruption phase, although ATC will not normally initiate a clearance through a danger area, it will inform aircraft about the hazard and will continue to provide normal services. It is expected that aircraft will attempt to remain clear of the danger area; however, it is the responsibility of the pilot-in-command to determine the safest course of action.

3.2.4 During the start of eruption phase the ACC should:

a) ensure a NOTAM is originated to define a danger area delineated cautiously so as to encompass a volume of airspace in accordance with the limited information available. In determining the area, information on upper winds should be taken into account, if available. The purpose is to ensure safety of flight in the absence of any prediction from a competent authority of the extent of contamination;

b) maintain close liaison with MET facilities (its associated MWO and the AFI VAAC, Toulouse),who should issue appropriate MET messages (“start of eruption” SIGMET message by the most expeditious means) in accordance with Annex 3;

c) devise and update ATFM measures when necessary to ensure safety of flight operations, based on these forecasts and in cooperation with aircraft operators and the adjacent ACCs using the CDM process;

d) ensure that reported differences between published information and observations (pilot reports, airborne measurements, etc.) are forwarded as soon as possible to the appropriate authorities to ensure its dissemination to all concerned;

e) begin planning for the on-going eruption phase in conjunction with the aircraft operators, the appropriate ATFM unit/ACCs concerned; and

f) issue appropriate AIS messages in accordance with Annex 15, should significant reductions in intensity of volcanic activity take place during this phase and the airspace no longer is contaminated by volcanic ash. Otherwise, begin CDM planning for the on-going eruption phase in conjunction with aircraft operators, the appropriate ATFM unit and the affected ACCs.

3.3 Adjacent ACC Actions

3.3.1 During the start of eruption phase adjacent ACCs should take the following actions:

a) maintain close liaison with the appropriate ATFM unit and the originating ACC to design, implement and keep up to date ATFM/ACC measures which will enable aircraft to ensure safety of flight operations.

b) the adjacent ACC, in cooperation with the originating ACC and aircraft operators, should impose as required additional tactical measures to those issued by the appropriate ATFM unit;

c) maintain awareness of the affected area; and

d) begin planning for the on-going eruption phase in conjunction with the aircraft operators, the appropriate ATFM unit and the ACCs concerned.

3.4. ATFM UNIT ACTIONS (where established)

3.4.1. During the start of eruption phase, depending on the impact and/or extent of the volcanic ash, the appropriate ATFM unit should organise the exchange of latest information on the developments with the associated VAACs, ANSPs, MWOs and operators concerned in order to support CDM.

4. ONGOING ERUPTION PHASE

4.1 The on-going eruption phase commences with the issuance of the first volcanic ash advisory (VAA) by the Toulouse VAAC which contains information on the extent and movement of the volcanic ash cloud in accordance with Annex 3 provisions.

Note. — Volcanic ash advisory information in graphical format (VAG) may also be issued by the VAAC, containing the same information as its text-based VAA equivalent.

4.2 The VAA/VAG should be used to prepare appropriate AIS and MET messages in accordance with Annex 15 and Annex 3 provisions respectively, and plan and apply appropriate ATFM measures.

4.3 The volcanic contamination may affect any combination of airspace; therefore, it is not possible to prescribe measures to be taken for all situations. Furthermore it not possible to detail the actions to be taken by any particular ACC. The following guidance therefore may prove useful during the on-going eruption phase but should not be considered mandatory or exhaustive:

a) ACCs affected by the movement of the volcanic ash should ensure that appropriate AIS messages areoriginated in accordance with Annex 15. ACCs concerned and the appropriate ATFM unit should continue to publish details on measures taken to ensure dissemination to all concerned;

b) depending on the impact and/or extent of the volcanic ash, the appropriate ATFM unit/ACC may take the initiative to organise teleconferences to exchange latest information on the developments, in order to support CDM, with the VAACs, ANSPs and MWOs and operators concerned;

c) ACCs and ATFM units should be aware that for the purposes of flight planning, operators could treat the horizontal and vertical extent of the volcanic ash contaminated area to be over-flown as if it were mountainous terrain; and

d) any reported differences between published information and observations (pilot reports, airborne measurements, etc.) should be forwarded as soon as possible to the appropriate (see **Appendix C).**

5. RECOVERY PHASE

5.1 The recovery phase commences with the issuance of the first VAA/VAG containing a statement that "NO VA EXP" (i.e. no volcanic ash expected") - which normally occurs when it is determined that the volcanic activity has reverted to its pre-eruption state and the airspace is no longer affected by volcanic ash contamination. Consequently, appropriate AIS messages (i.e. NOTAMC cancelling the active NOTAM, and a new NOTAM/ASHTAM) should be issued in accordance with Annex 15.

5.2. ACCs and ATFM units should revert to normal operations as soon as practical.

6. AIR TRAFFIC CONTROL PROCEDURES5

6.1 If volcanic ash cloud is reported or forecasted in the FIR for which the ATS unit is responsible, the following actions should be taken:

a) relay all pertinent information immediately to flight crews whose aircraft could be affected to ensure that they are aware of the ash cloud's position and levels affected;

b) request the intention of the flight crew and endeavour to accommodate requests for re-routing or level changes;

c) suggest appropriate re-routing to the flight crew to avoid an area of reported or forecast ash clouds; and;

d) request a special air-report when the route of flight takes the aircraft into or near the forecast ash cloud and provide such special air-report to the appropriate agencies.

Note 1.— The recommended escape manoeuvre for an aircraft which has encountered an ash cloud is to reverse its course and begin a descent if terrain permits.

Note 2. — The final authority as to the disposition of the aircraft, whether it be to avoid or proceed through a reported or forecast volcanic ash cloud, rests with the flight crew.

6.2
When advised by the flight crew that the aircraft has inadvertently entered a volcanic ash cloud, the ATS unit should:

a) take such action applicable to an aircraft in an emergency situation; and

b) not initiate modifications of route or level assigned unless requested by the flight crew or necessitated by airspace requirements or traffic conditions.

Note 1.— General procedures to be applied when a pilot reports an emergency situation are contained in Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM, Doc 4444) Chapter 15, 15.1.1 and 15.1.2.

Note 2.— Guidance material concerning the effect of volcanic ash and the impact of volcanic ash on aviation operational and support services is provided in Chapters 4 and 5 of the Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds (Doc 9691).

7. ATFM PROCEDURES

7.1. Depending on the impact and/or extent of the volcanic ash and in order to support CDM, the appropriate ATFM unit should organize the exchange of the latest information on the developments with the associated VAACs, ANSPs, MWOs and operators concerned.

7.2. The ATFM unit will apply ATFM measures on request of the ANSPs concerned. The measures should be reviewed and updated in accordance with updated information. Operators should also be advised to maintain watch for relevant AIS and MET messages for the area.

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APPENDIX A - GENERAL CONSIDERATIONS DURINGTHE DEVELOPMENT OF AN ATM CONTINGENCY PLAN FOR VOLCANIC ASH[3]

1. In a contingency plan relating to volcanic contamination, certain steps need to be taken to provide a coordinated and controlled response for dealing with an event of this nature. Responsibilities should be clearly defined to ATS personnel.. The plan should also identify the officials who need to be contacted, the type of messages that are to be created, the proper distribution of the messages and how to conduct business.

2. ATS personnel need to be trained and be made aware of the potentially hazardous effects if an aircraft encounters a volcanic ash cloud. Some particular aspects include:

a) volcanic ash contamination may extend for hundreds, or even thousands of miles horizontally and reach the stratosphere vertically;

b) volcanic ash may block the pitot-static system of an aircraft, resulting in unreliable airspeed indications;

c) braking conditions at airports where volcanic ash has recently been deposited on the runway will affect the braking ability of the aircraft. This is more pronounced on runways contaminated with wet ash. Flight crewsand ATS personnel should be aware of the consequences of volcanic ash being ingested into the engines during landing and taxiing. For departure, it is recommended that pilots avoid operating in visible airborne ash; instead they should allow sufficient time for the particles to settle before initiating a take-off roll, in order to avoid ingestion of ash particles into the engine. In addition, the movement area to be used should be carefully swept before any engine is started;

d) volcanic ash may result in the failure or power loss of one or all engines of an aircraft; and

e) aerodromes with volcanic ash deposition may be declared unsafe for flight operations. This might have consequences for the ATM system.

4. The area control centre (ACC) in conjunction with air traffic flow management (ATFM) units, where established, serves as the critical communication link between affected aircraft in flight and the information providers during a volcanic eruption. During episodes of volcanic ash contamination within the flight information region (FIR), the ACC has two major communication roles. First and most important is its ability to communicate directly with aircraft en-route which may encounter the ash. Based on the information provided in SIGMET information for volcanic ash and volcanic ash advisories (VAAs) and working with meteorological watch offices (MWOs), ATS personnel should be able to advise the flight crew of which flight levels are affected by the ash and the forecast movement of the contamination. Through the use of various communication means, ATS units have the capability to coordinate with the flight crew alternative routes which would keep the aircraft away from the volcanic ash cloud..

5. Similarly, through the origination of a NOTAM/ASHTAM for volcanic activity the ACC can disseminate information on the status and activity of a volcano even for pre-eruption increases in volcanic activity. NOTAM/ASHTAM and SIGMET, together with AIREPs, are critical to dispatchers for flight planning purposes. Operators need as much advance notification as possible on the status of a volcano for strategic planning of flights and the safety of the flying public. Dispatchers need to be in communication with flight crews en-route so that a coordinated decision can be made between the flight crew, the dispatcher and ATS regarding alternative routes that are available. The ACC should advise the ATFM unit concerning the availability of alternative routes. It cannot be presumed, however, that an aircraft which is projected to encounter ash will be provided with the most desirable route to avoid the contamination. Other considerations have to be taken into account such as existing traffic levels on other routes and the amount of fuel reserve available for flights which may have to be diverted to other routes to allow for the affected aircraft to divert.

6. The NOTAM/ASHTAM for volcanic activity provides information on the status of activity of a volcano when a change in its activity is, or is expected to be, of operational significance. They are originated by the ACC and issued through the respective international NOTAM office based on the information received from any one of the observing sources and/or advisory information provided by Toulouse Volcanic Ash Advisory Centre (VAAC). In addition to providing the status of activity of a volcano, the NOTAM/ASHTAM also provides information on the location, extent and movement of the ash contamination and the air routes and flight levels affected. NOTAM can also be used to limit access to the airspace affected by the volcanic ash. Complete guidance on the issuance of NOTAM and ASHTAM is provided in Annex 15 — *Aeronautical Information Services*. Included in Annex 15 is a volcano level of activity colour code chart. The colour code chart alert may be used to provide information on the status of the volcano, with "red" being the most severe, i.e. volcanic eruption in progress with an ash column/cloud reported above flight level 250, and "green" at the other extreme being volcanic activity considered to have ceased and volcano reverted to its normal pre-eruption state. It is very important that NOTAM for volcanic ash be cancelled and ASHTAM be updated as soon as the volcano has reverted to its normal pre-eruption status, no further eruptions are expected by volcanologists and no volcanic ash is detectable or reported within the FIR concerned.

7. It is essential that the procedures to be followed by ATS personnel during a volcanic eruption, as well as supporting services such as MET, AIS and ATFM, should be translated into local staff instructions (adjusted as necessary to take account of local circumstances). It is also essential that such local staff instructions form part of the basic training for all ATS, AIS, ATFM and MET personnel whose jobs would require them to take action in accordance with the procedures. Background information to assist the ACC or flight information centre (FIC) in maintaining an awareness of the status of activity of volcanoes in their FIR(s) is provided in the monthly Scientific Event Alert Network Bulletin published by the United States Smithsonian Institution and sent free of charge to ACCs/FICs requesting it.

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APPENDIX B - ANTICIPATED PILOT ISSUES WHEN ENCOUNTERING VOLCANIC ASH

1. ATS personnel should be aware that flight crews will be immediately dealing with some or all of the following issues when they encounter volcanic ash:

a) smoke or dust appearing in the cockpit which may prompt the flight crew to don oxygen masks (could interfere with the clarity of voice communications);

b) acrid odour similar to electrical smoke;

c) multiple engine malfunctions, such as stalls, increasing exhaust gas temperature (EGT), torching, flameout, and thrust loss causing an immediate departure from assigned altitude;

d) on engine restart attempts, engines may accelerate to idle very slowly, especially at high altitudes (could result in inability to maintain altitude or Mach number);

e) at night, St. Elmo's fire/static discharges may be observed around the windshield, accompanied by a bright orange glow in the engine inlet(s);

f) possible loss of visibility due to cockpit windows becoming cracked or discoloured, due to the sandblast effect of the ash;

g) because of the abrasive effects of volcanic ash on windshields and landing lights, visibility for approach and landing may be markedly reduced. Forward visibility may be limited to that which is available through the side windows; and/or

h) sharp distinct shadows cast by landing lights as compared to the diffused shadows observed in clouds (this affects visual perception of objects outside the aircraft).

2. Simultaneously, ATS personnel can expect flight crews to be executing contingency procedures such as the following:

a) if possible, the flight crew may immediately reduce thrust to idle;

b) exit volcanic ash cloud as quickly as possible. The shortest distance/time out of the ash may require an immediate, descending 180-degree turn (terrain permitting);

c) don flight crew oxygen masks at 100 per cent (if required);

d) monitor airspeed and pitch attitude. If unreliable airspeed is suspected, or a complete loss of airspeed indication occurs (volcanic ash may block the pitot system), the flight crew will establish the appropriate pitch attitude;

i) land at the nearest suitable airport; and

j) on landing, reverses may be used as lightly as feasible.

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APPENDIX C - COMMUNICATION AND DISSEMINATION OF PILOT REPORTS OF VOLCANIC ACTIVITY

1. INTRODUCTION

1.1 ICAO Annex 3 — Meteorological Service for International Air Navigation (paragraph 5.5, g) and h)) prescribes that volcanic ash clouds, volcanic eruptions and pre-eruption volcanic activity, when observed, shall be reported by all aircraft. The ICAO Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM, Doc 4444) contain detailed provisions on this special air report requirement in paragraphs 4.12.3 and 4.12.5, and the Volcanic Activity Report form in Appendix 1.

1.2 Experience has shown that reporting and sharing of information on volcanic ash encounters in accordance with the above mentioned provisions (in-flight and post-flight) varies across the world. The efficiency and quality of reporting currently depends heavily on regional characteristics and the level of regional integration. A high level of global harmonization is essential to achieve the desired level of implementation and consistency of the information.

2. PURPOSES OF VOLCANIC ASH REPORTING AND DATA COLLECTION

2.1 The main purposes for volcanic ash reporting and data collection are to:

a) locate the volcanic hazards:

b) notify immediately other aircraft (in-flight) about the hazard;

c) notify other interested parties: ANSPs (ATC, AIS, ATFM), VAACs, MWO, etc to ensure the consistent production of appropriate information and warning products in accordance with existing provisions;

d) analyse collected reports from the post-flight phase in order to:

i) identify areas of concern;

ii) validate and improve volcanic ash forecasts;

iii) improve existing procedures;

iv) assist in defining better airworthiness requirements; and

v) share lessons learned, etc.

3. PHASE OF OPERATIONS

3.1 The roles and responsibilities of the participants in the collection, exchange and dissemination of the volcanic information are distinctly different in two distinct phases:

a) in-flight; and

b) post-flight.

3.2 The following section analyses these separately.

4. PARTICIPANTS IN THE REPORTING PROCESS, THEIR ROLES AND RESPONSIBILITIES

4.1 Identification of the participants as well as their roles and responsibilities in general, but specifically during the two different phases of operations, is an important element in improving collection, exchange and dissemination of volcanic information. The number of participants and their roles and responsibilities depends on

the phase of operations (in-flight, post-flight), their position in the information chain within one of these two phases and national/regional arrangements. One of the main issues regarding participants' roles and responsibilities is that each of them is, at one time or another, both a data/information provider and user of the information.

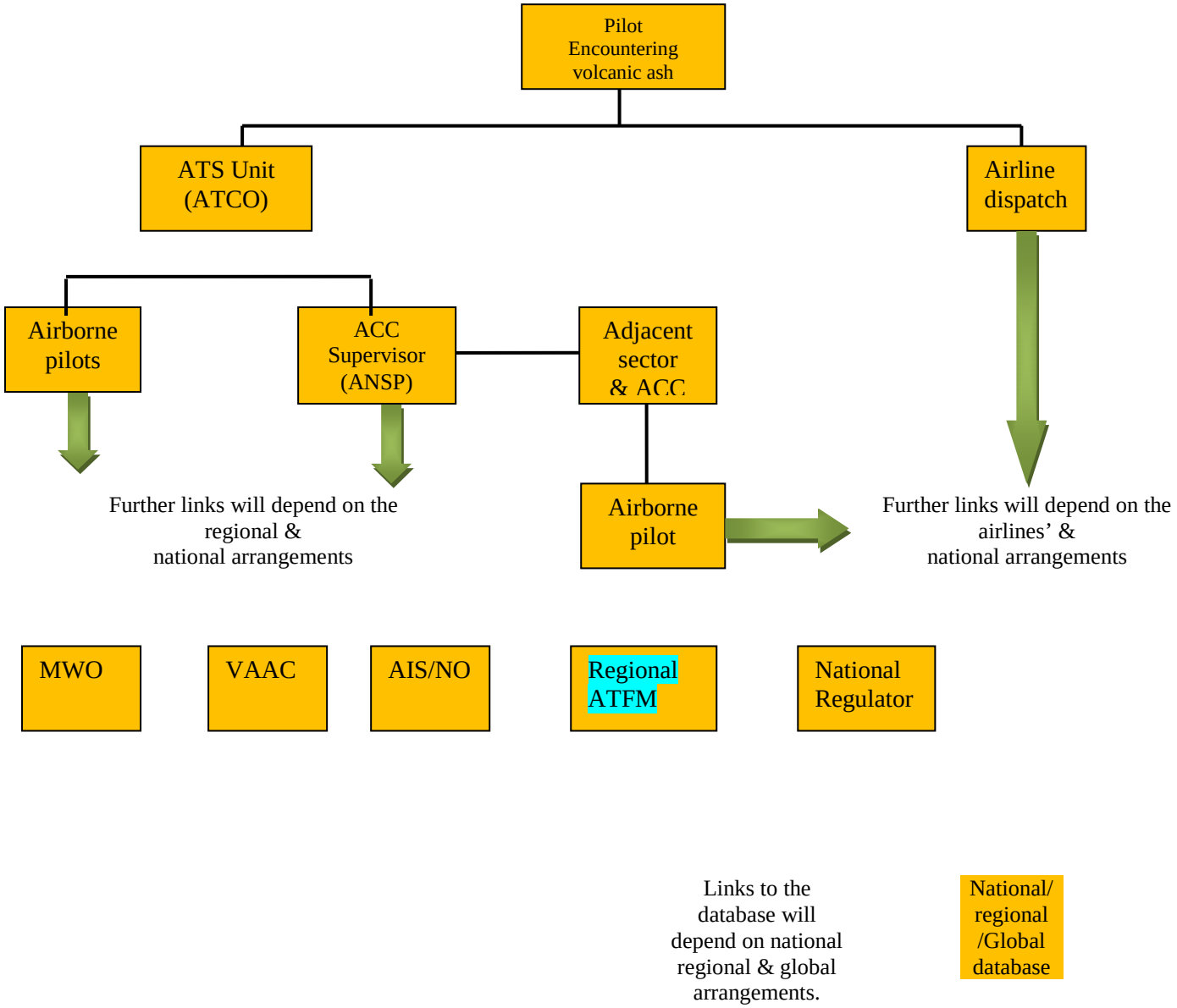
4.2 In-Flight Phase

4.2.1 Participants, Roles & Responsibilities

	Participants	Roles & Responsibilities
1	Pilots, civil and/or military, observing and/or encountering volcanic activity	To provide as much detailed information as possible about the type, position, colour, smell, dimensions of the volcanic contamination, level and time of the observation and forward VAR Part I immediately to the ATS unit with which the pilot is in radiotelephony (R/T) communication. Record the information required for VAR Part II on the appropriate form as soon as possible after the observation or encounter, and file the report via data link, if available.
2	ATS unit receiving the information from the pilot encountering volcanic event	To ensure that information received by an air traffic controller from the pilot has been copied, clarified (if necessary) and disseminated to other pilots as well as to the ACC Supervisor. In addition, air traffic controllers could ask other pilots flying within the same area if they have observed any volcanic activity
3	ATS unit/ACC Supervisor (if applicable) or other responsible person within the Air Navigation Service Provider	To use all means of communication and available forms to ensure that the information received from the air traffic controller has been: • passed on to the associated Meteorological organizations in accordance with national/regional arrangements; • fully and immediately disseminated across the organization, in particular to adjacent sectors and the associated NOTAM Office (NOF); • passed on to the neighbouring sectors and ACCs (if necessary); • passed on to the regional ATFM centre if existing (e.g. CFMU in AFI); • passed on to the national/regional authority responsible for the handling of contingency situations
4	Neighbouring ANSPs (ACCs etc.)	To ensure that information is provided to flight crews flying towards the area affected by the volcanic contamination; disseminated across the organization and the system prepared to cope with the possible changes of the traffic flows; and that the information is provided to the national authority responsible for the handling of contingency situations and passed on to the NOF and MWO as required
5	MET Watch Office	To use the information originated by flight crews and forwarded by the ATS unit which received the information in accordance with Annex 3
6	VAAC	To use the information originated by flight crews, MWOs and other competent sources in accordance with Annex 3
7	AIS / NOF	To publish appropriate AIS messages in accordance with Annex 15
8	ATFM unit or centre (if existing)	To ensure that information received is stored and made available for information to all partners in its area of responsibility (ANSPs, airlines, VAAC, MET etc.). As part of the daily activity, coordinate ATFM measures with ACCs concerned.

4.2.2 In-flight reporting – Sample Flow Chart of the volcanic ash information

4.2.2.1 The chart below is a graphical representation of a possible path of the in-flight volcanic ash information and may differ between regions depending on regional arrangements. It also gives the position of the volcanic ash participants in the reporting chain. The flow chart is not exhaustive and the path of the information can be extended and new participants could be added depending of the national and regional requirements.



4.3 Post-Flight Operations Roles & Responsibilities and order of reporting

	Participants	Roles & Responsibilities
1	Civil and/or military pilots/airlines having observed or encountered an eruption or volcanic contamination	To file the volcanic ash report with as much detailed information as possible about the volcanic activity and/or encounter (position, colour, smell, dimensions, FL, time of observation, impact on the flight, etc.). Ensure that the VAR is filed and transmitted to the relevant recipients as soon as possible after landing (if not filed via datalink already during the flight). Make an entry into the Aircraft Maintenance Log (AML) in case of an actual or suspected encounter with volcanic contamination
2	ANSP	To provide a summary report of effects of the volcanic activity that affected its operations at least once per day to the national authority with as much detailed information as possible about the number of

		encounters, impact on air traffic management, etc.)
3	AOC Maintenance - Post flight Inspection	To report about the observation of the aircraft surfaces, engine, etc, and to provide the information to the national (or regional or global, where applicable) central data repository
4	Investigation authority	All aeronautical service providers (including operators, ANSPs, airports, etc) shall investigate the effects of a volcanic activity, analyze the information and search for conclusions; and report the investigation results and relevant information to the national supervisory authority and any central data repository.
5	National Authority	To handle the national central data repository and report to the regional/global central data repository if any. To analyze reports from its aeronautical service providers and take action as appropriate
6	Regional Central Data Repository	To collect the national data and make them available to interested stakeholders under agreed conditions
7	MWO	To use the national and regional information coming from national and regional central data repositories
8	VAAC	To use the information originated by flight crews, and other competent sources to: a) validate its products accordingly and; a) b) improve the forecast
9	Global Data Repository (and research institutes - where appropriate)	To analyse the information stored in the regional central data repository and provide the research outcomes for lessons learnt process.
10	Knowledge management (e.g. SKYbrary)	To use the post-flight lessons learnt and disseminate them to interested stakeholders.
11	ICAO	To review/revise ATM volcanic ash contingency plans.

4.4 Tools for presenting and sharing the volcanic ash information

4.4.1 To report, transmit and disseminate the volcanic ash encounter information, different types of tools can be used. The list below is provided to give ideas as to what tools can be used. It could also be split into regulatory and general information tools. At any case, it is not an exhaustive list and can be updated with new elements depending on regional experiences.

a) Radiotelephony and Data link Communications

b) VAR

c) NOTAM/ASHTAM

d) SIGMET

e) VAA/VAG

f) Central data repository e.g. CFMU Network Operations Portal (NOP)

g) Centralized web based sites with the regularly updated information and maps – e.g. EVITA - http://www.eurocontrol.int/services/evita-european-crisis-visualisation-interactive-tool-atfcm

h) Teleconferences

i) Periodic Bulletins with the set of information defined by the data providers and data users; e.g. Smithsonian Institution Weekly Bulletin.

j) Centralized internet-based sites for the sharing of lessons learnt (Knowledge management – e.g. SKYbrary http://www.skybrary.aero/index.php/Main_Page)

- END -

APPENDIX D- ACTION TAKEN BY METEOROLOGICAL WATCH OFFICES (MWO) IN THE EVENT OF A VOLCANIC ERUPTION[4]

1. On receipt of information of a volcanic eruption and/or the existence of volcanic ash, the MWO will:

a) Notify, if necessary, the AFI VAAC (Toulouse) designated to provide VAA/VAG for the FIR for which the MWO is responsible that a volcanic eruption and/or ash has been reported. In the event that the MWO becomes aware, from a source other than an ACC, of the occurrence of pre-eruption activity, a volcanic eruption or ash from any other source , the information will be passed with all available relevant details on the extent, forecast movement of volcanic ash immediately to the ACC and to the designated VAAC;

b) Reported differences between ash encounters by aircraft and the information published in VAA/VAG, SIGMET or NOTAM/ASHTAM received by an ACC shall be made available as soon as possible to the respective MWO, preferably in the form of an AIREP. The MWO will relay the information to the respective originators of the published information;

c) Notify adjacent MWOs designated to provide SIGMET that a volcanic eruption and/or ash cloud has been reported, provide available relevant details on the extent, forecast movement of volcanic ash. In the event that any other MWO becomes aware of the occurrence of volcanic ash cloud from any source other than the VAAC, the information should be passed immediately to the VAAC and any adjacent MWO(s) downstream of the moving ash cloud;

d) As soon as practicable, advise the ACC and the VAAC whether or not the volcanic ash is identifiable from satellite images/data, ground based or airborne measurements or other relevant sources;

e) Issue SIGMET relating to the horizontal and vertical extent of volcanic ash cloud and its expected movement (provided in the VA from Toulouse VAAC) for a validity period of up to 6 hours. The SIGMET shall include an observed (or forecast) position of the ash cloud at the *start* of the period of validity, and a forecast position at the *end* of the period of validity. The SIGMET should be based on the advisory information provided by the VAAC. Include in the SIGMET distribution list the two Regional OPMET Databanks (RODBs) in Dakar and Johannesburg (Pretoria RODB). As well as inter-regional distribution, the RODBs will ensure dissemination of the SIGMET to ~~all~~ the VAAC, the London World Area Forecast Centre (WAFC) and the AFI Bulletin Compiling Centres (BCC);

f) provide information to assist with the origination of NOTAM by ACCs and maintain continuous coordination with ACCs, adjacent MWOs and the VAAC concerned to ensure consistency in the issuance and content of SIGMET and NOTAM/ASHTAM; and

g) provide, if possible, regular volcanic briefings, based on the latest available ash observations and forecasts, to ACCs, Airport Operators and aircraft operators concerned, giving an outlook for beyond T+12 hours.

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[4] This information is adapted from the *Handbook on the International Airways Volcano Watch (IAVW)* (Doc 9766). Refer to this document for full details.

APPENDIX E: ACTION TO BE TAKEN BY THE AFI VAAC IN THE EVENT OF A VOLCANIC ERUPTION[5]

1. On receipt of information from a MWO or any other source, of significant pre-eruptive/eruption activity and/or a volcanic ash cloud observed, the VAAC should:

a) Initiate the volcanic ash computer trajectory/dispersal model in order to provide advisory information on volcanic ash trajectory to MWOs, ACCs and operators concerned;

b) Review satellite images/data and any available pilot reports of the area for the time of the event to ascertain whether a volcanic ash cloud is identifiable and, if so, its extent and movement;

c) Prepare and issue advisories on the extent, and forecast trajectory, of the volcanic ash contamination in message format for transmission to the MWOs, ACCs and operators concerned in the VAAC area of responsibility, and to the two Regional OPMET Data Banks (RODB) in Dakar and Pretoria. As well as inter-regional distribution, the RODBs will ensure dissemination of the advisory to all VAACs, the London World Area Forecast Centre (WAFC);

d) Monitor subsequent satellite information or other available observations to assist in tracking the movement of the volcanic ash;

e) Continue to issue advisory information (i.e. VAA/VAG), for validity periods T+0, T+6, T+12 and T+18 hours after data time, to MWOs, ACCs and operators concerned at least at 6 hour intervals, and preferably more frequently, until such time as it is considered that the volcanic ash 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; and

f) Maintain regular contact with other VAACs and meteorological offices concerned, and, as necessary, the Smithsonian Institute Global Volcanism Network, in order to keep up to date on the activity status of volcanoes in the VAAC area of responsibility.

END

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[5] This information is adapted from the *Handbook on the International Airways Volcano Watch (IAVW)* (Doc 9766). Refer to this document for full details.

APPENDIX F RECOMMENDED ACTIONS BY STATES OF THE OPERATOR/REGISTRY WITH REGARDS TO AIRCRAFT OPERATIONS IN THE EVENT OF A VOLCANIC ERUPTION

Safety Risk Assessments For Flights In Airspace Proximate To Volcanic Ash

1 Introduction

1.1 It is recommended that States of the Operator/Registry as appropriate which intend to allow operators under their jurisdiction to operate in areas of volcanic ash contamination consider requiring operators to carry out a safety risk assessment prior to carrying out such operations.

1.2 Safety risk assessments should be completed prior to planned operations in airspace or to/from aerodromes which may be contaminated by volcanic ash.

2 Applicability

2.1 All operators conducting flights in airspace and/or to/from aerodromes which could be affected by volcanic ash.

3 Recommendations

3.1 In accordance with ICAO Annex 6, Chapter 3, paragraph 3.3- Safety Management, it is recommended that States of the Operator/Registry as appropriate require all operators, planning to operate in areas where the presence of volcanic ash is forecast, to carry out a safety risk assessment prior to planned operations. The safety risk assessment should include a requirement for the operator to:

a) Conduct their own risk assessment and develop operational procedures to address any remaining risks;

b) Put in place appropriate maintenance ash damage inspections; and

c) Ensure that any ash related incidents are reported by AIREP and followed up by a Volcanic Activity Report (VAR).

3.2 Guidance in the preparation of such a safety risk assessment is provided in **APPENDIX H** of this document.

APPENDIX G EXAMPLE SAFETY RISK ASSESSMENT PROCESS

1 Introduction

1.1 The safety risk assessment process is described in the *Safety Management Manual* (Doc 9859) .The process involves identifying the hazards associated with the activity (in this case airspace proximate to volcanic ash or flying to and from aerodromes affected by volcanic ash), considering the seriousness of the consequences of the hazard occurring (the severity), evaluating the likelihood or probability of it happening, deciding whether the consequent risk is acceptable and within the organisation's safety performance criteria (acceptability), and finally taking action to reduce the safety risk to an acceptable level (mitigation).

2 Hazard Identification

2.1 A hazard is any situation or condition that has the potential to cause adverse consequences. A suggested list of topics, that is not necessarily exhaustive, to be considered is attached at **APPENDIX I.**

3 The Safety Risk Assessment

3.1 Risk is an assessment of the likelihood and the severity of adverse consequences resulting from a hazard.

3.2 To help an operator decide on the likelihood of a hazard causing harm, and to assist with possible mitigation of any perceived safety risk, all relevant stakeholders should be consulted.

3.3 The safety risk from each hazard should be assessed using a suitably calibrated safety risk assessment matrix. An example risk assessment matrix is given in *Safety Management Manual* (Doc 9859) but an alternative which aligns with an organisation's own Safety Management System (SMS) would be equally appropriate. The safety risk should be derived by considering the severity of the safety outcome arising from the hazard, together with the likelihood of the outcome.

3.4 The severity of any adverse consequences resulting from a particular hazard should be assessed using a suitably calibrated severity scale. Example scales are given in *Safety Management Manual* (Doc 9859) but an alternative, which aligns with an organisation's own SMS, would be equally appropriate. Note that, for any flight, the safety outcome of a volcanic ash encounter may be significant.

3.5 Risk Likelihood

3.5.1 The likelihood or probability of adverse consequences resulting from a particular hazard should then be assessed. The likelihood should be agreed using a suitably calibrated likelihood or probability scale. An example probability scale is given in *Safety Management Manual* (Doc 9859), but an alternative which aligns with an organisation's own SMS would be equally appropriate.

3.5.2 When assessing likelihood or probability the following factors should be taken into account:

- The degree of exposure to the hazard.
- Any historic incident or safety event data relating to the hazard. This can be derived from data from industry, regulators, other operators, Air Navigation Service Providers, internal reports etc.
- The expert judgement of relevant stakeholders.

3.5.3 The results of the assessment should be recorded in a hazard log, sometimes referred to as a risk register. An example of a hazard log is at **APPENDIX J**.

3.6 Risk Tolerability

3.6.1 At this stage of the process the safety risks should be classified in a range from acceptable to unacceptable. A suitable set of definitions for Risk Classification is given in *Safety Management Manual* (Doc 9859).

3.6.2 Appropriate mitigations for each identified hazard should then be considered, recorded on the hazard log and implemented. Mitigations must be adopted in order to reduce the safety risks to an acceptable level, but additional mitigation wherever reasonably practicable should also be considered where this might reduce an already acceptable safety risk even further. Thus, the mitigation process should reduce the safety risk to be as low as reasonably practicable.

3.6.3 Not all hazards can be suitably mitigated in which case the operation should not proceed.

3.7 Mitigating Actions

3.7.1 Mitigating actions by themselves can introduce new hazards. Where an organisation has an effective SMS then procedures will exist for continual monitoring of hazard, risk and involvement of qualified personnel in accepting the mitigating actions or otherwise. Operators without an effective SMS should repeat the safety risk assessment following any mitigation process and at regular intervals as the circumstances on which the original assessment was predicated may have changed. This ensures ongoing safety management or monitoring.

3.8 Records

3.8.1 The results of the safety risk assessment should be documented and promulgated throughout the organisation and submitted to the operator's national safety authority. Actions should be completed and mitigations verified and supported by evidence prior to the start of operations.

3.8.2 Any assumptions should be clearly stated and the safety risk assessment reviewed at regular intervals to ensure the assumptions and decisions remain valid.

3.8.3 Any safety performance monitoring requirements should also be identified and undertaken through the organisation's safety management processes.

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APPENDIX H **EXAMPLE TABLE OF CONSIDERATIONS FOR PLANNED OPERATIONS IN AIRSPACE OR TO/FROM AERODROMES WHICH MAY BE CONTAMINATED BY VOLCANIC ASH.**

Considerations	Guidance
Operator Procedures	
Type Certificate Holder Guidance	Operators must obtain advice from the Type Certificate Holder and engine manufacturer concerning both operations in potentially contaminated airspace and/or to/from aerodromes contaminated by volcanic ash, including subsequent maintenance action.
Guidance for Company Personnel	Publish procedures for flight planning, operations and maintenance. Review of flight crew procedures for detection of volcanic ash and associated escape manoeuvres. Type Certificate Holder advice on operations to/from aerodromes contaminated by volcanic ash including performance.
Flight Planning	These considerations will be applicable to all flights that plan to operate in airspace or to/from aerodromes which may be contaminated by volcanic ash.
NOTAM and ASHTAM	The operator must closely monitor NOTAM and ASHTAM to ensure that the latest information concerning volcanic ash is available to crews.
SIGMETs	The operator must closely monitor SIGMETs to ensure that the latest information concerning volcanic ash is available to crews.
Departure, Destination and any Alternates	Degree of contamination, additional performance, procedures and maintenance consideration.
Routing Policy	Shortest period in and over contaminated area.
Diversion Policy	Maximum allowed distance from a suitable alternate. Availability of alternates outside contaminated area. Diversion policy after an ash encounter.
Minimum Equipment List / Dispatch Deviation Guide	Consider additional restrictions for dispatching aircraft: • air conditioning packs; • engine bleeds; • air data computers; • standby instruments; • navigation systems; • Auxiliary Power Unit (APU); • Airborne Collision Avoidance System (ACAS); • Terrain Awareness Warning System (TAWS); • provision of crew oxygen; and • supplemental oxygen for passengers. (This list is not necessarily exhaustive.)

Considerations	Guidance
Operator Procedures	
Provision of Enhanced Flight Watch	Timely information to and from crew of latest information.
Fuel Policy	Consideration to the carriage of extra fuel.

Considerations	Guidance
Crew Procedures	These considerations will be applicable to all flights that plan to operate in airspace or to/from aerodromes which may be contaminated by volcanic ash.
Pilot Reports	Requirements for reporting in the event of an airborne encounter. Post-flight reporting.
Mandatory Occurrence Reports	Reminder regarding the necessity for filing MORs following an encounter.
Standard Operating Procedures	Review changes to normal and abnormal operating procedures: • pre-flight planning; • operations to/from aerodromes contaminated with volcanic ash; • supplemental oxygen; • engine-out procedures; and • escape routes. (This list is not necessarily exhaustive.)

Technical Log	Any actual or suspected volcanic ash encounter will require a tech log entry and appropriate maintenance action prior to subsequent flight. Penetration (detail and duration) of airspace or operations to/from aerodromes which may be contaminated by volcanic ash will require a tech log entry.

Considerations	Guidance
Maintenance Procedures	Operators, who are operating in areas of ash contamination, are recommended to enhance vigilance during inspections and regular maintenance and potentially adjust their maintenance practices, based upon the observations, to prevent unscheduled maintenance. Observations should include signs of unusual or accelerated abrasions, corrosion and / or ash accumulation. Operator co-operation is requested in reporting to manufacturers and the relevant authorities their observations and experiences from operations in areas of ash contamination. If significant observations are discovered beyond normal variations currently known, manufacturers will share these observations, and any improved recommendations for maintenance practices, with all operators and the relevant authorities.

Note: The above list is not necessarily exhaustive and operators must make their own assessments of the hazards on the specific routes they fly.

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APPENDIX I EXAMPLE OF A HAZARD LOG (RISK REGISTER)

HAZARD		Incident Sequence Description	Existing Controls	Outcome (Pre-Mitigation)			Additional Mitigation Required	Outcome (Post-Mitigation)			Actions and Owners	Monitoring and Review Requirements
No.	Description			Severity	Likelihood	Risk		Severity	Likelihood	Risk		

(Add additional rows as necessary)

APPENDIX J - EXAMPLE SIGMET, NOTAM, ASHTAM

Guidance on WMO headers referred to in Alerting Phase, paragraph 1.2.2 refers can be found in WMO No.386 Volume I (*Manual of Global Telecommunications System)* Part II *(Operational Procedures for the Global Telecommunications System)*

NOTAM Offices are reminded that ASHTAM (or NOTAM for volcanic ash) should be distributed via AFTN to their associated MWO, the SADIS Gateway and all the VAAC, in accordance with guidelines contained in ICAO Doc 9766 Chapter 4 paragraph 4.3.

1. SIGMET

```
WVUK02 EGRR 180105
EGGX SIGMET 2 VALID 180105/180705 EGRR-
EGGX SHANWICK OCEANIC FIR VA ERUPTION MT KATLA PSN N6337 W01901 VA CLD
OBS AT 0100Z N6100 W02730 - N6100 W02230 - N5800 W01730 - N5630 W02000
FL200/350 MOV SE 35KT FCST 0705Z VA CLD APRX N5800 W02000 - N5730
W01200 - N5500 W00910 - N5430 W01530 - N5800 W02000=
```

Note: PSN replaces LOC as per Amendment 75 to Annex 3 (applicable 18 November 2010)

2. NOTAM alerting pre-eruptive activity

```
(A0777/10NOTAMN
Q) BIRD/QWWXX/IV/NBO/W/000/999/6337N01901WXXX
A) BIRD B) 1002260830 C) 1002261100  E) INCREASED VOLCANIC ACTIVITY,
POSSIBLY INDICATING IMMINENT ERUPTION, REPORTED FOR VOLCANO KATLA
1702-03 6337.5N01901.5W ICELAND-S. VOLCANIC ASHCLOUD IS EXPECTED TO
REACH 50,000 FEET FEW MINUTES FROM START OF ERUPTION.AIRCRAFT ARE
REQUIRED TO FLIGHT PLAN TO REMAIN AT LEAST XXXNM CLEAR OF VOLCANO AND
MAINTAIN WATCH FOR NOTAM/SIGMET FOR AREA.
F) GND G) UNL)
```

Note: XXX is a distance established by the Provider State in accordance with paragraph 1.2.1 a)

3. NOTAM establishing Danger Area after initial eruption

```
(A0778/10 NOTAMR A0777/10
Q) BIRD/QWWXX/IV/NBO/W/000/999/6337N01901WXXX
A) BIRD
B) 1002260900 C) 1002261200
E) VOLCANIC ERUPTION REPORTED IN VOLCANO KATLA 1702-03 6337.5N01901.5W
ICELAND-S. VOLCANIC ASHCLOUD REPORTED REACHING FL500. AIRCRAFT ARE
REQUIRED TO REMAIN AT LEAST XXXNM CLEAR OF VOLCANO AND MAINTAIN WATCH
FOR NOTAM/SIGMET FOR BIRD AREA.
F) GND G) UNL)
```

Note: XXX is a distance established by the Provider State in accordance with paragraph 1.2.1 a)

4. NOTAM establishing Danger Area to include Area of High [or High/Medium or High/Medium/Low] Contamination

```
(A0503/10 NOTAMN
Q)EGGN/QWWXX/IV/NBO/AE/000/350
A) EGPX B) 1005182300 C) 1005190500
```

```
E) TEMPORARY DANGER AREA HAS BEEN ESTABLISHED FOR VOLCANIC ASH AREA OF
HIGH CONTAMINATION IN AREA 5812N00611W 5718N00216W 5552N00426W
5629N00652W
F) SFC
G) FL350)
```

5. NOTAM to define Area of Medium Contamination for which a Danger Area has not been established

```
(A0207/10 NOTAMN
Q) EUEC/QWWXX/IV/AE/000/200
A) EIAA B) 1005190700 C) 1005191300
E) VOLCANIC ASH AREA OF MEDIUM CONTAMINATION FORECAST IN AREA
5243N00853W 5330N00618W 5150N00829W
F) SFC
G) FL200)
```

6. ASHTAM alerting pre-eruptive activity

```
VALI0021 LIRR  01091410
ASHTAM 005/10
A) ROMA FIR B) 01091350 C) ETNA 101-06 D) 3744N01500E
E) YELLOW ALERT
J) VULCANOLOGICAL AGENCY
```

7. ASHTAM alerting eruptive activity

```
VALI0024 LIRR  01151800
ASHTAM 015/10
A) ROMA FIR B) 01151650 C) ETNA 101-06 D) 3744N01500E
E) RED ALERT F) AREA AFFECTED 3700N01500E 3900N01600E 3800N001700W
SFC/35000FT  G) NE H) ROUTES AFFECTED WILL BE NOTIFIED BY ATC  J)
VULCANOLOGICAL AGENCY
```

8. ASHTAM alerting reduction in eruptive activity

```
VALI0035 LIRR  01300450
ASHTAM 025/10
A) ROMA FIR B) 01300350 C) ETNA 101-06 D) 3744N01500E
E) YELLOW ALERT FOLLOWING ORANGE J) VULCANOLOGICAL AGENCY
```

APPENDIX K – MAJOR VOLCANOES IN THE AFI REGION

MAJOR VOLCANOES IN THE AFI REGION

	Volcano Name	Volcano Type	Volcano Status	Location
1	TAHALRA VOLCANIC FIELD	Pyroclastic cones	Holocene	Algeria
2	ATAKOR VOLCANIC FIELD	Scoria cones	Holocene	Algeria
3	MANZAZ VOLCANIC FIELD	Scoria cones	Holocene	Algeria
4	IN EZZANE VOLCANIC FIELD	Volcanic field	*Holocene*	Algeria-Niger border
5	CAMEROON	Stratovolcano	Historical	Cameroon
6	TOMBEL GRABEN	Cinder cones	Holocene	Cameroon
7	MANENGOUBA	Stratovolcano	*Holocene*	Cameroon
8	OKU VOLCANIC FIELD	Stratovolcano	*Holocene*	Cameroon
9	NGAOUNDERE PLATEAU	Volcanic field	*Holocene*	Cameroon
10	LA PALMA	Stratovolcanoes	Historical	Canary Islands
11	HIERRO	Shield volcano	Radiocarbon	Canary Islands
12	TENERIFE	Stratovolcano	Historical	Canary Islands
13	GRAN CANARIA	Fissure vents	Radiocarbon	Canary Islands
14	FUERTEVENTURA	Fissure vents	Holocene	Canary Islands
15	LANZAROTE	Fissure vents	Historical	Canary Islands
16	FOGO	Stratovolcano	Historical	Cape Verde Islands
17	BRAVA	Stratovolcano	Holocene	Cape Verde Islands
18	SAO VICENTE	Stratovolcano	Holocene	Cape Verde Islands
19	TARSO TOH	Volcanic field	Holocene	Chad
20	TARSO TOUSSIDE	Stratovolcano	Holocene	Chad
21	TARSO VOON	Stratovolcano	Fumarolic	Chad
22	EMI KOUSSI	Pyroclastic shield	Holocene	Chad
23	LA GRILLE	Shield volcano	Holocene	Comore Island
24	KARTHALA	Shield volcano	Historical	Comore Island
25	KARISIMBI	Stratovolcano	Potassium-Argon	Democratic Republic Congo-Rwanda border
26	VISOKE	Stratovolcano	Historical	Democratic Republic Congo-Rwanda border
27	MAY-YA-MOTO	Fumarole field	Fumarolic	Democratic Republic of Congo
28	NYAMURAGIRA	Shield volcano	Historical	Democratic Republic of Congo
29	NYIRAGONGO	Stratovolcano	Historical	Democratic Republic of Congo
30	TSHIBINDA	Cinder cones	Holocene	Democratic Republic of Congo
31	ARDOUKOBA	Fissure vents	Historical	Djibouti
32	GARBES	Fumarole field	*Pleistocene-*	Djibouti
33	BOINA	Fumarole field	*Pleistocene-*	Djibouti-Ethiopia border
34	JALUA	Stratovolcano	Holocene	Eritrea
35	ALID	Stratovolcano	Holocene	Eritrea
36	DUBBI	Stratovolcano	Historical	Eritrea
37	NABRO	Stratovolcano	*Holocene?*	Eritrea
38	ASSAB VOLCANIC FIELD	Volcanic field	Holocene	Eritrea
39	GUFA	Volcanic field	Holocene	Eritrea-Djibouti border
40	DALLOL	Explosion craters	Historical	Ethiopia
41	GADA ALE	Stratovolcano	Holocene	Ethiopia
42	ALU	Fissure vents	Holocene	Ethiopia
43	DALAFFILLA	Stratovolcano	Historical	Ethiopia
44	BORALE ALE	Stratovolcano	Holocene	Ethiopia
45	ERTA ALE	Shield volcano	Historical	Ethiopia
46	ALE BAGU	Stratovolcano	Holocene	Ethiopia
47	HAYLI GUBBI	Shield volcano	Holocene	Ethiopia
48	ASAVYO	Shield volcano	Holocene	Ethiopia
49	MAT ALA	Shield volcano	Holocene	Ethiopia
50	TAT ALI	Shield volcano	Holocene	Ethiopia
51	BORAWLI	Stratovolcano	Holocene	Ethiopia
52	AFDERA	Stratovolcano	*Holocene?*	Ethiopia
53	MA ALALTA	Stratovolcano	Holocene	Ethiopia
54	ALAYTA	Shield volcano	Historical	Ethiopia
55	DABBAHU	Stratovolcano	Historical	Ethiopia

MAJOR VOLCANOES IN THE AFI REGION

	Volcano Name	Volcano Type	Volcano Status	Location
56	DABBAYRA	Shield volcano	Holocene	Ethiopia
57	MANDA HARARO	Shield volcanoes	Historical	Ethiopia
58	GROPPO	Stratovolcano	Holocene	Ethiopia
59	KURUB	Shield volcano	Holocene	Ethiopia
60	MANDA GARGORI	Fissure vents	Anthropology	Ethiopia
61	BORAWLI	Lava domes	Holocene	Ethiopia
62	DAMA ALI	Shield volcano	Historical	Ethiopia
63	GABILLEMA	Stratovolcano	Holocene	Ethiopia
64	YANGUDI	Complex volcano	Holocene	Ethiopia
65	AYELU	Stratovolcano	Holocene	Ethiopia
66	ADWA	Stratovolcano	Holocene	Ethiopia
67	HERTALI	Fissure vent	Holocene	Ethiopia
68	LIADO HAYK	Maars	*Holocene?*	Ethiopia
69	DOFEN	Stratovolcano	Holocene	Ethiopia
70	FENTALE	Stratovolcano	Historical	Ethiopia
71	BERU	Volcanic field	Holocene	Ethiopia
72	KONE	Calderas	Historical	Ethiopia
73	UNNAMED	Pyroclastic cones	Holocene	Ethiopia
74	BOSET-BERICHA	Stratovolcanoes	Holocene	Ethiopia
75	BISHOFTU VOLCANIC FIELD	Fissure vents	Holocene	Ethiopia
76	UNNAMED	Fissure vents	Holocene	Ethiopia
77	SODORE	Pyroclastic cones	Holocene	Ethiopia
78	GEDAMSA	Caldera	Holocene	Ethiopia
79	BORA-BERICCIO	Pumice cones	Holocene	Ethiopia
80	TULLU MOJE	Pumice cone	Anthropology	Ethiopia
81	UNNAMED	Fissure vents	Holocene	Ethiopia
82	EAST ZWAY	Fissure vents	Holocene	Ethiopia
83	BUTAJIRI-SILTI FIELD	Fissure vents	Holocene	Ethiopia
84	ALUTU	Stratovolcano	Radiocarbon	Ethiopia
85	O'A CALDERA	Caldera	Holocene	Ethiopia
86	CORBETTI CALDERA	Caldera	Holocene	Ethiopia
87	BILATE RIVER FIELD	Maars	Holocene	Ethiopia
88	TEPI	Shield volcano	Holocene	Ethiopia
89	HOBICHA CALDERA	Caldera	*Holocene?*	Ethiopia
90	CHIRACHA	Stratovolcano	*Holocene?*	Ethiopia
91	TOSA SUCHA	Cinder cones	Holocene	Ethiopia
92	UNNAMED	Cinder cones	Holocene	Ethiopia
93	KORATH RANGE	Tuff cones	*Holocene?*	Ethiopia
94	MALLAHLE	Stratovolcano	*Holocene?*	Ethiopia/Eritrea
95	SORK ALE	Stratovolcano	*Holocene?*	Ethiopia/Eritrea
96	MANDA-INAKIR	Fissure vents	Historical	Ethiopia-Djibouti border
97	MOUSA ALLI	Stratovolcano	Holocene	Ethiopia-Eritrea-Djibouti border
98	MEGA BASALT FIELD	Pyroclastic cones	Holocene	Ethiopia-Kenya border
99	NORTH ISLAND	Tuff cones	Holocene	Kenya
100	CENTRAL ISLAND	Tuff cones	Holocene	Kenya
101	SOUTH ISLAND	Stratovolcano	Historical	Kenya
102	MARSABIT	Shield volcano	*Holocene?*	Kenya
103	THE BARRIER	Shield volcano	Historical	Kenya
104	NAMARUNU	Shield volcano	Tephrochronology	Kenya
105	SEGERERUA PLATEAU	Pyroclastic cones	Holocene	Kenya
106	EMURUANGOGOLAK	Shield volcano	Radiocarbon	Kenya
107	SILALI	Shield volcano	Ar/Ar	Kenya
108	PAKA	Shield volcano	Ar/Ar	Kenya
109	BOGORIA	Shield volcano	*Pleistocene-Geysers*	Kenya

MAJOR VOLCANOES IN THE AFI REGION

	Volcano Name	Volcano Type	Volcano Status	Location
110	KOROSI	Shield volcano	Holocene	Kenya
111	OL KOKWE	Shield volcano	Holocene	Kenya
112	NYAMBENI HILLS	Shield volcano	Holocene	Kenya
113	MENENGAI	Shield volcano	Tephrochronology	Kenya
114	HOMA MOUNTAIN	Complex volcano	Holocene	Kenya
115	ELMENTEITA BADLANDS	Pyroclastic cones	Holocene	Kenya
116	OL DOINYO EBURRU	Complex volcano	Holocene	Kenya
117	OLKARIA	Pumice cones	Radiocarbon	Kenya
118	LONGONOT	Stratovolcano	Anthropology	Kenya
119	SUSWA	Shield volcano	Holocene	Kenya
120	CHYULU HILLS	Volcanic field	Anthropology	Kenya
121	HARUJ	Volcanic field	Holocene	Libya
122	WAU-EN-NAMUS	Caldera	*Holocene?*	Libya
123	AMBRE-BOBAOMBY	Volcanic field	Holocene	Madagascar
124	NOSY-BE	Cinder cones	Holocene	Madagascar
125	ANKAIZINA FIELD	Cinder cones	Holocene	Madagascar
126	ITASY VOLCANIC FIELD	Scoria cones	Radiocarbon	Madagascar
127	ANKARATRA FIELD	Cinder cones	Holocene	Madagascar
128	MADEIRA	Shield volcano	Radiocarbon	Madeira
129	TIN ZAOUATENE VOLCANIC FIELD	Volcanic field	Holocene	Mali
131	TODRA VOLCANIC FIELD	Cinder cones	Holocene	Niger
132	BIU PLATEAU	Volcanic field	*Holocene?*	Nigeria
133	PITON DE LA FOURNAISE	Shield volcano	Historical	Reunion Island
134	SAO TOME	Shield volcano	*Holocene?*	Sao Tome and Principe
135	JEBEL MARRA	Volcanic field	Radiocarbon	Sudan
136	KUTUM VOLCANIC FIELD	Scoria cones	*Holocene?*	Sudan
137	MEIDOB VOLCANIC FIELD	Scoria cones	Holocene	Sudan
138	BAYUDA VOLCANIC FIELD	Cinder cones	Radiocarbon	Sudan
139	JEBEL UMM ARAFIEB	Shield volcano	*Holocene?*	Sudan
140	OL DOINYO LENGAI	Stratovolcano	Historical	Tanzania
141	KILIMANJARO	Stratovolcano	Holocene	Tanzania
142	MERU	Stratovolcano	Historical	Tanzania
143	IGWISI HILLS	Tuff cones	Holocene	Tanzania
144	UNNAMED	Pyroclastic cone	Holocene	Tanzania
145	SW USANGU BASIN	Lava domes	Holocene	Tanzania
146	NGOZI	Caldera	Radiocarbon	Tanzania
147	IZUMBWE-MPOLI	Pyroclastic cones	Holocene	Tanzania
148	RUNGWE	Stratovolcano	Radiocarbon	Tanzania
149	KYEJO	Stratovolcano	Historical	Tanzania
150	FORT PORTAL	Tuff cones	Radiocarbon	Uganda
151	KYATWA	Tuff cones	*Holocene?*	Uganda
152	KATWE-KIKORONGO	Tuff cones	Holocene	Uganda
153	BUNYARUGURU	Maars	Holocene	Uganda
154	KATUNGA	Tuff cone	Holocene	Uganda
155	BUFUMBIRA	Cinder cones	*Holocene?*	Uganda
156	MUHAVURA	Stratovolcano	Holocene	Uganda-Rwanda border

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