

INTERNATIONAL CIVIL AVIATION ORGANIZATION



VOLCANIC ASH CONTINGENCY PLAN

AFI REGION

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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 **Attachment F** (source: Smithsonian Institution).

The AFI Volcanic Ash Contingency Plan sets out standardised guidelines for the alerting of aircraft when eruptions occur, and procedures to be followed.

Volcanic ash is a hazard for flight operations. Recent encounters with volcanic ash have resulted in one or more of the following and other problems:

- Engine failures and malfunctions;
- Subsequent failure of electrical, pneumatical and hydraulic systems;
- Blocking of sensors, resulting inter alia in erroneous airspeed indications;
- Smoke, dust and/or chemical pollution of cabin air; resulting in the need for aircrews to use oxygen masks;
- Communication problems;
- Loss of visibility through cockpit windows.

Regulatory authorities of States of the Operator¹, or State of Registry² as appropriate, should therefore prescribe appropriate operational procedures for flight crew to be followed in case of operation in or near airspaces that are contaminated by volcanic ash. Operators are required by ICAO Annex 6 to assess the risk of operation in volcanic ash and to implement appropriate mitigation measures in accordance with their Safety Management System as approved by the State of the Operator.

It should be noted that this document is an air traffic management (ATM) contingency plan including its interfaces with supporting services such as MET and AIS and that the Plan therefore primarily addresses the Provider States³. Where distinct actions by the Meteorological Watch Offices (MWOs) are described, these are additional procedures to be considered by MWOs. Where actions by Volcanic Ash Advisory Centre (VAAC) and Aircraft Operators are described, these are for clarification only.

Volcanic Ash can also affect the operation of aircraft on aerodromes. In extreme cases, aerodromes might no longer be available for operation at all, resulting in repercussions on the Air Traffic Management systems; e.g. diversions, revised traffic flow, etc.

These suggested procedures are not intended to establish or confirm a safe level of ash concentration. Operation through any area where volcanic ash is forecast is at the discretion of the operator.

NOTE: *All modeled ash concentrations are subject to a level of uncertainty relative to errors in the estimation of the eruption strength.*

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, timely response to reports of volcanic ash is essential.

It is imperative that information on the volcanic activity is disseminated as soon as possible. In order to assist the staff in expediting the process in originating and issuing relevant messages (SIGMET, NOTAM, ASHTAM), a series of templates should be available for different stages of the volcanic activity. Examples of SIGMET, NOTAM and ASHTAM announcing volcanic activities in the different stages and operational measures are contained in **Attachment E**. ASHTAM is promulgated by service providers in the AFI Region, APIRG/16 Conclusion 16/52 refers.

¹ The term "State of the Operator" refers to the role of a Contracting State as the regulatory authority with regard to aircraft operators having been issued an Aircraft Operator's Certificate (AOC) by that State.

² The term "State of Registry" refers to the State on whose register the aircraft is entered.

³ The term "Provider State" refers to the role of a Contracting State as responsible for the provision of air navigation services within airspace over its territory and, as agreed by Regional Air Navigation Meeting, within defined airspace over the High Seas.

A list of ICAO registered volcanoes should be available at the international NOTAM office with volcano name, number and nominal position. The volcanoes in the AFI region are listed in **Attachment F**.

In order to ensure the smooth implementation of the contingency plan in case of an actual volcanic eruption, annual AFI ATM/MET Volcanic Ash Exercises (VAEX/AFI) should be conducted.

Terminology

Area of Low Contamination: An airspace of defined dimensions where volcanic ash may be encountered at concentrations equal to or less than $2 \times 10^{-3} \text{ g/m}^3$.

Area of Medium Contamination: An airspace of defined dimensions where volcanic ash may be encountered at concentrations greater than $2 \times 10^{-3} \text{ g/m}^3$, but less than $4 \times 10^{-3} \text{ g/m}^3$.

Area of High Contamination: An airspace of defined dimensions where volcanic ash may be encountered at concentrations equal to or greater than $4 \times 10^{-3} \text{ g/m}^3$, or areas of contaminated airspace where no ash concentration guidance is available.

Note 1: Concentration areas are defined by the MET office co-located with the AFI VAAC: Toulouse MET Office.

Note 2: "defined dimensions" refers to horizontal and vertical limits.

The response to a volcanic event **that affects air traffic** has been divided into three distinct phases described briefly below. Volcanic activity at many locations is continuously monitored by the scientific community. Furthermore, flight crew are required to report observations of significant volcanic activity by means of a Special Air Report (Special AIREP). Arrangements are in place to ensure that such information is transferred without undue delay to the appropriate aeronautical institutions responsible for subsequent action:

ALERTING PHASE The initial response, "**raising the alert**", commences when a volcanic eruption is expected. Alerting information will be provided by SIGMET, NOTAM or ASHTAM as appropriate and disseminated to affected aircraft in flight by the most expeditious means. In addition to the normal distribution list, the NOTAM/ASHTAM will be addressed to meteorological and volcanological agencies.

If it is considered that the event could pose a hazard to aviation, a Danger Area⁴ will be declared by NOTAM around the volcanic source. Normally, clearances will not be issued through the Danger Area.

REACTIVE PHASE The Reactive Phase commences at the outbreak of the volcanic eruption and entrance of volcanic ash into the atmosphere and mainly pertains to aircraft in flight. A "**Start of eruption SIGMET**" will be issued and a Danger Area will be declared by NOTAM. Clearances will not be issued through the Danger Area.

PROACTIVE PHASE The Proactive Phase commences with the issuance of the first Volcanic Ash Advisory (VAA) and Volcanic Ash Graphic (VAG) after completion of reactive responses. Supplementary modelled ash concentration charts may be available. The volcanic ash forecasts up to T+18 hours are to be used to prepare SIGMET. SIGMET shall be issued as soon as practicable but not more than 12 hours before the commencement of the period of validity, and shall be valid for up to 6 hours. The T+12 hours and T+18 hours (and further into the future, if available) volcanic ash forecasts are to be used to prepare NOTAM/ASHTAM. Significant changes may result in a reversion to a temporary Reactive Phase situation and unscheduled issuance of VAA, VAG and ash concentration charts by Toulouse VAAC, SIGMET and NOTAM/ASHTAM. As appropriate, Danger Areas will be notified via NOTAM.

Note that where SIGMET and NOTAM are mentioned in this document, volcanic ash SIGMET and volcanic ash NOTAM are being referred to.

⁴ 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.

This document pays due respect to Standards and Recommended Practices in ICAO Annexes, WMO procedures, and guidance material contained in ICAO documents, including, but not limited to, the following:

ICAO Annex 3 – *Meteorological Services for International Air Navigation*; ICAO Annex 11 – *Air Traffic Services*; ICAO Annex 15 – *Aeronautical Information Services*; ICAO Doc 4444 – *Procedures for Air Navigation Services – Air Traffic Management*; ICAO Doc 8126 – *Aeronautical Information Services Manual*; ICAO Doc 8896 – *Manual of Aeronautical Meteorological Practice*; ICAO Doc 9691 – *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds*; ICAO Doc 9766 – *Handbook on the International Airways Volcanic Watch*; ICAO Doc 9859 – *Safety Management Manual*; ICAO AFI SIGMET Guide; and WMO No.386 Volume I (*Manual of Global Telecommunications System*) Part II (*Operational Procedures for the Global Telecommunications System*).

1. ALERTING PHASE

1.1 This phase is characterised by a limited availability of information on the extent and severity of the volcanic event. The purpose of this phase is to ensure the safety of aircraft in flight and to promulgate information as a matter of urgency. Regardless of the extent of information available the alerting phase actions should be carried out for every event.

1.2 ORIGINATING AREA CONTROL CENTRE (ACC) ACTIONS (eruption in its own flight information region (FIR))

1.2.1 In the event of significant pre-eruption volcanic activity, a volcanic eruption occurring, or a volcanic ash cloud being reported which could pose a hazard to aviation, an ACC, on receiving information of such an occurrence, should carry out the following actions:

- a) Define an initial Danger Area in accordance with established procedures, or if no such procedures have been established the danger area should be defined as a circle with a radius of 222 km (120 NM). If the eruption has not commenced or if no information on upper winds is available, the circle should be centred on the estimated location of the volcanic activity. If the eruption has started and predicted upper wind information is available, the circle should be centred 111 km (60 NM) downwind from while enclosing the volcano. The purpose of this initial Danger Area is to ensure safety of flight in the absence of any prediction from a competent authority of the extent of contamination.
- b) Advise the associated Meteorological Watch Office (MWO) and the appropriate Volcanic Ash Centre (VAAC) (unless the initial notification originated from either of these entities). The VAAC will then inform the appropriate ACCs.
- c) Alert flights already within the Danger Area and offer assistance to enable aircraft to exit the area in the most expeditious and appropriate manner. Aircraft that are close to the Danger Area should be offered assistance to keep clear of the area. Tactically re-clear flights which would penetrate the Danger Area onto routes that will keep them clear. The ACC should immediately notify other affected ACC's of the event and the location and dimensions of the Danger Area. It should also negotiate any re-routings necessary for flights already coordinated but still within adjacent flight information regions (FIRs). It is also expected that adjacent ACCs will be asked to reroute flights not yet coordinated to keep them clear of the Danger Area.
- d) Ensure that a NOTAM/ASHTAM is originated. This must provide as precise information as is available regarding the activity of the volcano. The name (where applicable), reference number and position of the volcano should be included along with the date and time of the start of the eruption (if appropriate). It is imperative that this information is issued by the international NOTAM office and disseminated as soon as possible.
- e) In order to assist the staff in expediting the process of composing the NOTAM/ASHTAM, a series of templates should be available for this stage of the volcanic activity. Example NOTAM and ASHTAM are provided in **Attachment E**.

1.2.2 In addition to sending the NOTAM/ASHTAM and any subsequent NOTAM/ASHTAM to the normal distribution list, it will be sent to the relevant meteorological agencies after adding the appropriate World Meteorological Organization (WMO) header. Example NOTAM and ASHTAM are provided in **Attachment E**.

1.3 ADJACENT ACC ACTIONS

1.3.1 During the Alerting Phase aircraft should be tactically rerouted to avoid the Danger Area. 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.
- b) Unless otherwise instructed, continue normal operations except:
 - i) if one or more routes are affected by the Danger Area, stop clearing aircraft on these routes and take steps to reroute onto routes clear of the Danger Area; and
 - ii) initiate a running plot of the affected area.

2. REACTIVE PHASE

2.1 This phase commences at the outbreak of volcanic eruption. Major activities of the Reactive Phase are: Issuance of an eruption commenced SIGMET, eruption commenced NOTAM/ASHTAM and rerouting of airborne traffic. As appropriate, Danger Areas will be notified via NOTAM. This phase will last until such time as the Proactive Phase can be activated.

2.2 ORIGINATING ACC ACTIONS (eruption in its own FIR)

2.2.1 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 conduct of flights.

2.2.2 Rerouting of traffic commences immediately or may be in progress if the alerting time has been sufficient to facilitate activation of the Alerting 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.

2.2.3 During this phase the ACC should:

- a) Maintain close liaison with its associated MWO. The MWO should issue a SIGMET message on the extent and forecast movement of the ash cloud based on appropriate sources of information.
- b) Ensure a NOTAM is originated to define a Danger Area.
- c) Ensure that reported differences between published information and observations (pilot reports, airborne measurements, etc.) are forwarded as soon as possible to the appropriate authorities.
- d) Should significant reductions in intensity of volcanic activity take place during this phase and the airspace no longer is contaminated by volcanic ash, a NOTAMC cancelling the last active NOTAM shall be issued stating the cause for cancellation; new ASHTAM should be promulgated to update the situation. Otherwise, begin planning for the Proactive Phase in conjunction with the affected ACCs.

2.3 ADJACENT ACC ACTIONS

2.3.1 During the Reactive Phase the adjacent ACCs should take the following action:

- a) Maintain close liaison with the originating ACC to design, implement and keep up to date measures which will enable aircraft to remain clear of Danger Areas.
- b) In the event that tactical measures are required, the adjacent ACC should, in cooperation with the originating ACC, impose such measures. .
- c) Maintain a running plot of the affected area.
- d) Begin planning for the Proactive Phase in conjunction with the appropriate ACCs concerned.

3. PROACTIVE PHASE

3.1 The Proactive Phase commences with the issuance of the first VAA/VAG by Toulouse VAAC after completion of the reactive responses. The VAA/VAG will contain forecasts of the expected vertical and horizontal extent of the volcanic ash cloud, and its expected movement, at six-hourly time-steps for the period T+0 to T+18 hours. In addition, the meteorological office co-located with the VAAC will issue ash concentration forecasts to supplement the VAA/VAG information, at six-hourly intervals with a nominal validity time of 0000Z, 0600Z, 1200Z and 1800Z which will define Areas of Low, Medium and High Contamination.

3.2 Following the Reactive Phase, the VAA/VAG and (where available) ash concentration forecasts should be used to define airspace volumes encompassing the furthest extent of contamination predicted for that period. These volumes should be used to:

- a) publish NOTAM indicating the extent of Danger Areas, indicating which areas of contamination are included therein;
- b) issue SIGMET warning of potential hazard from areas of volcanic ash contamination;
- c) publish NOTAM to separately indicate the extent of Areas of Medium Contamination if not included in a Danger Area.

3.3 Longer term forecasts (i.e. beyond T+6 hours) should be used to generate NOTAM in order to ensure that adequate information is available to support flight planning. These messages should differentiate between levels of contamination.

3.4 Operators should use the information published regarding Areas of Low, Medium and High Contamination to plan their flights in accordance with their regulatory requirements and the service that will be provided in the airspace concerned. Operators should be aware that, depending on the State concerned, Danger Areas may be established to contain an Area of High Contamination, Areas of Medium/High Contamination, or Areas of Low/Medium/High Contamination.

3.5 The volcanic ash may affect any combination of airspace; therefore, it is impossible to prescribe measures to be taken for any particular situation. Nor is it possible to detail the actions to be taken by any particular ACC. The following guidance may prove useful during the Proactive Phase but should not be considered mandatory:

- a) ACCs affected by the movement of the ash should continue to originate NOTAM/ASHTAM at appropriate intervals. ACCs concerned should continue to publish details on measures taken.
- b) Depending on the impact of the volcanic ash, the appropriate ACC may take the initiative to organise teleconferences to exchange latest information on the developments with Toulouse VAAC, ANSPs and MWO's and operators concerned.
- c) During this phase the VAAC should endeavour to assess the vertical extent of the ash contamination and provide appropriate VAA/VAG to define the contaminated airspace as accurately as possible. For the purpose of flight planning, operators should treat the horizontal and vertical limits of the Danger Area to be over-flown as they would mountainous terrain. Operators are cautioned regarding the risk of cabin depressurisation or engine failure resulting in the inability to maintain level flight above the Danger Area, especially where Extended Twin Operations (ETOPS) aircraft are involved.
- d) Any reported differences between published information and observations (pilot reports, airborne measurements, etc.) should be forwarded as soon as possible to the appropriate authorities; and

- e) When the airspace is no longer contaminated by volcanic ash, a NOTAMC cancelling the active NOTAM shall be promulgated. New ASHTAM should be promulgated to update the situation.

4. AIR TRAFFIC CONTROL PROCEDURES⁵

4.1 If volcanic ash is reported or forecast in the FIR for which the ACC is responsible, the following procedures should be followed:

- a) relay all available information immediately to pilots whose aircraft could be affected to ensure that they are aware of the horizontal and vertical extent of the ash contamination;
- b) if requested, suggest appropriate rerouting to assist flights to avoid areas of known or forecast ash contamination;
- c) When appropriate, remind pilots that volcanic ash may not be detected by ATC radar systems;
- d) If modelled ash concentration charts are available showing Areas of Low, Medium and High Contamination, the Provider State may establish Danger Areas. Depending on the State concerned, the Danger Areas will be established to contain an Area of High Contamination, Areas of Medium/High Contamination, or Areas of Low/Medium/High Contamination;
- e) In the absence of ash concentration guidance, the entire area of forecast volcanic ash should be considered as an Area of High Contamination, for the purposes of applying ATC procedures, until ash concentration guidance is available;
- f) Normally, ATC should not provide a clearance for an aircraft to enter or operate within a Danger Area. Assistance to enable an aircraft to exit a Danger Area in the most expeditious and appropriate manner should be provided;
- g) If the ACC has been advised by an aircraft that it has entered an area of ash contamination and indicates that a distress situation exists:
 - i) consider the aircraft to be in an emergency situation;
 - ii) do not initiate any climb clearances to turbine-powered aircraft until the aircraft has exited the area of ash contamination; and
 - iii) do not attempt to provide vectors without pilot concurrence.

4.2 Experience has shown that the recommended escape manoeuvre for an aircraft which has encountered volcanic ash is to reverse its course and begin a descent (if terrain permits). However, the final responsibility for this decision rests with the pilot.

⁵ This information is adapted from the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691). Refer to this document for full details.

5. GENERAL GUIDANCE FOR THE DEVELOPMENT OF ATS CONTINGENCY PLANS FOR VOLCANIC ASH⁶

5.1 In a contingency plan relating to volcanic ash 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 for the manager in charge, supervisors and Air Traffic Controllers (ATCOs). 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.

5.2 ATCOs need to be trained and be made aware of the potential effects if aircraft encounter unsafe levels of volcanic ash.

5.3 Some particular points of guidance are as follows:

- a) Volcanic ash clouds may extend for hundreds 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. Pilots and ATCOs 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 aeroplane; and
- e) Airports might have to be declared unsafe for flight operations. This might have consequences for the ATM system.

5.4 The ACC serves as the critical communication link between the pilot, dispatcher and meteorologists during a volcanic eruption. During episodes of volcanic ash contamination within the FIR, the ACC has two major communication roles. First and of greatest importance is its ability to communicate directly with aircraft en route which may encounter the ash. Based on the information provided in the volcanic ash SIGMET and VAAs and working with MWO, the ATCOs should be able to advise the pilot of which flight levels are affected by the ash and the projected trajectory and drift of the contamination. Through the use of radio communication, ACCs have the capability to coordinate with the pilot alternative routes which would keep the aircraft away from the volcanic ash.

5.5 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 special 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 pilots en route so that a coordinated decision can be made between the pilot, the dispatcher and ATC regarding alternative routes that are available. 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.

5.6 The NOTAM/ASHTAM for volcanic activity provide 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 the Toulouse 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

⁶ This information is adapted from the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691). Refer to this document for full details.

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 ash is detectable or reported from the FIR concerned.

5.7 It is essential that the procedures which the ACC personnel, including supporting services such as MET and AIS should follow during a volcanic eruption/ash cloud event described in the foregoing paragraphs are translated into the local staff instructions (adjusted as necessary to take account of local circumstances). It is also essential that these procedures/instructions form part of the basic training for all MET, ATS and AIS 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 ICAO monthly International Airways Volcano Watch (IAVW) website at: <http://www2.icao.int/en/anb/met-aim/met/iavwopsg/Pages/default.aspx> under Worldwide Weekly Volcanic Activity Reports webpage. The major AFI volcanoes are listed in **Attachment F**.

ATTACHMENT A - ANTICIPATED PILOT ISSUES WHEN ENCOUNTERING VOLCANIC ASH

1. Air Traffic Controllers (ATCOs) 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) cockpit windows could be rendered completely opaque; 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, ATC can expect pilots to be executing contingency procedures. This may include a possible course reversal and/or an emergency descent.

**ATTACHMENT B - ACTION TAKEN BY METEOROLOGICAL WATCH OFFICES (MWO)
IN THE EVENT OF A VOLCANIC ERUPTION⁷**

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 and concentration 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 and (if known) concentration 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.

⁷ This information is adapted from the *Handbook on the International Airways Volcano Watch (IAVW)* (Doc 9766). Refer to this document for full details.

ATTACHMENT C - ACTION TO BE TAKEN BY THE AFI VAAC IN THE EVENT OF A VOLCANIC ERUPTION⁸

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.

⁸ This information is adapted from the *Handbook on the International Airways Volcano Watch (IAVW)* (Doc 9766). Refer to this document for full details.

ATTACHMENT D - PROCEDURES FOR THE PRODUCTION OF MODELLED ASH CONCENTRATION CHARTS

1. The following procedures are to be applied by the meteorological office of a Provider State, having accepted, by regional air navigation agreement, the responsibility for providing a VAAC within the framework of the International Airways Volcano Watch (IAVW).
2. All VAA and VAG information issued by a meteorological office under designation as a VAAC within the framework of the IAVW shall be prepared in accordance with ICAO provisions.
3. Additionally, where feasible, the meteorological office may issue modelled ash concentration charts and corresponding coordinate data files at 6-hourly intervals showing the different ash concentrations for the validity periods T+0, T+6, T+12 and T+18 hours after data time. These charts will show forecast ash distribution in terms of Areas of Low, Medium and High Contamination and be published at the same time, and with the same validity periods, as the VAA/VAG described above. Updated charts and data files should be distributed prior to the end of the validity time of those previously distributed.
4. These data may be used by Provider States to prepare SIGMET, NOTAM/ASHTAM and to establish Danger Areas as appropriate.

ATTACHMENT E - 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

ATTACHMENT F – 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	<i>Holocene</i>	Algeria-Niger border
5	CAMEROON	Stratovolcano	Historical	Cameroon
6	TOMBEL GRABEN	Cinder cones	Holocene	Cameroon
7	MANENGOUBA	Stratovolcano	<i>Holocene</i>	Cameroon
8	OKU VOLCANIC FIELD	Stratovolcano	<i>Holocene</i>	Cameroon
9	NGAOUNDERE PLATEAU	Volcanic field	<i>Holocene</i>	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	<i>Pleistocene-</i>	Djibouti
33	BOINA	Fumarole field	<i>Pleistocene-</i>	Djibouti-Ethiopia border
34	JALUA	Stratovolcano	Holocene	Eritrea
35	ALID	Stratovolcano	Holocene	Eritrea
36	DUBBI	Stratovolcano	Historical	Eritrea
37	NABRO	Stratovolcano	<i>Holocene?</i>	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	<i>Holocene?</i>	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	<i>Holocene?</i>	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	<i>Holocene?</i>	Ethiopia
90	CHIRACHA	Stratovolcano	<i>Holocene?</i>	Ethiopia
91	TOSA SUCHA	Cinder cones	Holocene	Ethiopia
92	UNNAMED	Cinder cones	Holocene	Ethiopia
93	KORATH RANGE	Tuff cones	<i>Holocene?</i>	Ethiopia
94	MALLAHLE	Stratovolcano	<i>Holocene?</i>	Ethiopia/Eritrea
95	SORK ALE	Stratovolcano	<i>Holocene?</i>	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	<i>Holocene?</i>	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	<i>Pleistocene-Geysers</i>	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	MENENGAJ	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	<i>Holocene?</i>	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	<i>Holocene?</i>	Nigeria
133	PITON DE LA FOURNAISE	Shield volcano	Historical	Reunion Island
134	SAO TOME	Shield volcano	<i>Holocene?</i>	Sao Tome and Principe
135	JEBEL MARRA	Volcanic field	Radiocarbon	Sudan
136	KUTUM VOLCANIC FIELD	Scoria cones	<i>Holocene?</i>	Sudan
137	MEIDOB VOLCANIC FIELD	Scoria cones	Holocene	Sudan
138	BAYUDA VOLCANIC FIELD	Cinder cones	Radiocarbon	Sudan
139	JEBEL UMM ARAFIEB	Shield volcano	<i>Holocene?</i>	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	<i>Holocene?</i>	Uganda
152	KATWE-KIKORONGO	Tuff cones	Holocene	Uganda
153	BUNYARUGURU	Maars	Holocene	Uganda
154	KATUNGA	Tuff cone	Holocene	Uganda
155	BUFUMBIRA	Cinder cones	<i>Holocene?</i>	Uganda
156	MUHAVURA	Stratovolcano	Holocene	Uganda-Rwanda border

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