

**Seventeenth Meeting of the Cross Polar Trans East Air Traffic Management Providers' Work Group
(CPWG/17)**

(Samara, Russia, 3-6 June 2014)

Agenda Item 5: Provide Status on CPWG/16 Actions

Volcanic Ash Contingency Plan - Update

(Action Item #15-08)

(Presented by Isavia)

SUMMARY

This working paper presents update to CPWG on amendments to NAT Volcanic Ash Contingency Plan following the amendment of PANS ATM 15.8 which is scheduled to take effect in November 2014.

1. Introduction

1.1 The International Volcanic Ash Task Force (IVATF) agreed to transfer the responsibility for Volcanic Ash (VA) avoidance or the decision to fly or not to fly into area of known or forecast VA contamination from Air Traffic Management (ATM) to Aircraft Operators (AO).

1.2 Subsequently an amendment to *Procedures for Air Navigation Services - Air Traffic Management* (ICAO DOC 444, PANS-ATM) was approved by the Air Navigation Commission (ANC) and pending the ICAO Council approval it was expected to take effect in November 2014.

1.3 The purpose of this working paper is to update Cross Polar Working Group with discussions and decisions made by NAT management groups on amendments to NAT Volcanic Ash Contingency Plan.

2. Discussion

2.1 The PANS-ATM amendment signals a significant change in procedures concerning VA where the responsibility of VA avoidance is transferred to the Aircraft Operators (AO). Following such a change there is a requirement to amend the Air Traffic Management (ATM) VA contingency plan to reflect the amended procedures where the role of ATM will no longer focus on decision-making but instead be the distribution of information and provision of assistance when requested.

2.2 The new proposal is based on the Air Traffic Management Volcanic Ash Contingency Plan Template published by ICAO, containing all relevant guidance concerning the handling of volcanic eruptions and taking into account of the shift in responsibility of VA avoidance (see appendix A).

2.3 The new proposal addresses the following main revisions/amendment to the current NAT Volcanic Ash Contingency Plan:

- a) Establishment of a Danger Area (airspace closed) at the start of eruption while information is not available;
- b) NOTAM distribution to include the notification of increased volcanic activity (eruption imminent), start of eruption, significant changes in the volcanic activity and end of eruption. NOTAMS will also list sources of information available to airspace users;
- c) ATM to pass SIGMET information to aircraft in flight. SIGMET to be distributed as well through other channels to Meteorological (MET) data banks and AOs. For flight planning purposes AOs can use the advisories issued by the Volcanic Ash Advisory Centres (VAACs);
- d) ATM to impose traffic flow restrictions as necessary to handle the air traffic safely;
- e) The NAT Organized Track System (OTS) should normally be designed to remain outside forecast contaminated areas. It was understood that any aircraft penetration into contaminated areas would be based on specific safety assessments that were expected to vary between aircraft operators. Therefore it was expected that ATM would not be able to take these into account in the OTS design. Designing an OTS through a contaminated area would also falsely lead operators to believe that operation on a published track within the contaminated area had been deemed to be safe without an (operator-specific) safety assessment.

2.4 The new proposal is still a working draft, not yet approved by NAT SPG.

2.5 Considering that the responsibility for VA avoidance would be transferred to the airspace users, the need for regional ATM VA exercises would need to be reassessed and the role and format of ATM VA exercises should be reevaluated.

3. Action by the Meeting

3.1 The meeting is invited to:

- a. note the information contained in this Working Paper;
- b. review the information contained in the proposed NAT Volcanic Ash Contingency Plan, Appendix A to this working paper.

**Appendix A – PROPOSED NEW NAT DOC 006, PART II VOLCANIC ASH CONTINGENCY
PLAN EUR AND NAT REGIONS**

Provided as a separate document

– END –

NAT Doc 006, Part II

INTERNATIONAL CIVIL AVIATION ORGANIZATION



VOLCANIC ASH CONTINGENCY PLAN

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NAT REGION

DRAFT

Edition 2014

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FOREWORD

This document is a NAT 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 pitot 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 verbal communication; 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 ash 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 ATM¹ 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–

¹ ATM is defined “the dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management – safely, economically and efficiently – through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions.” (*Procedures for Air Navigation Services – Air Traffic Management* (PANS-ATM, Doc 4444))

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 flows, etc.

Some aircraft types or engine technologies are more vulnerable to volcanic ash contaminants than others; therefore, any specific mitigation measures to be applied would have to take into account any such variance. Considering that a commercial aircraft travels about 150 km (80 NM) in 10 minutes and that volcanic ash can rise to flight levels commonly used by turbine-engine aircraft 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, 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 State's 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, volcanic ash exercises (VOLCEX) should be conducted at a frequency determined by the ICAO Region concerned.

This document has been prepared, and is in line with an 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 applicable from 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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AIR TRAFFIC MANAGEMENT VOLCANIC ASH CONTINGENCY PLAN TEMPLATE

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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 Annex 3 – *Meteorological Service for International Air Navigation*.²

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 — a 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 and MET 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 volcanic ash into the atmosphere and mainly pertains to aircraft in flight.

² Principally this will include volcanic ash advisory messages (issued by volcanic ash advisory centres) and SIGMET information on volcanic ash (issued by meteorological watch offices).

³ Depending on the State's regulation, the area may be established as a “danger area”, “restricted area” or “prohibited area”. Over the high seas only “danger area” may be established.

Appropriate AIS and MET 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) **ON-GOING ERUPTION PHASE:** The on-going 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 and MET 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 ash is expected in the atmosphere and the 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 volcanic activity by means of a special air-report (Special 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. The communication and dissemination of pilot reports on volcanic activity is described in 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 very 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

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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 a Special 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 should ensure that alerting information is provided expeditiously by the most appropriate means 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 ACC ACTIONS (*eruption expected in its own flight information region*)

2.2.1. In the event of significant pre-eruption volcanic activity, which could pose a hazard to aviation, an area control centre (ACC)⁴, 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;
 - 1) if no such procedures have been established, the danger area should be defined as a circle with a radius of xxx km (xx NM)⁵. The circle should be centred on the estimated or known location of the volcanic activity;
 - 2) 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.
- c) advise the associated MET service provider(s) in accordance with national/regional arrangements (unless the initial notification originated from such provider(s)), who will then inform the appropriate air traffic flow management (ATFM) units;

⁴ Where the term “ACC” is used throughout this document, it is intended to also include all ATS facilities.

⁵ The size of the area is to be agreed in the region concerned and should be based on local knowledge as regards the volcano concerned.

- 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. Aircraft that are close to the area should be offered assistance to remain clear of the 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 ACC should 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; and
- 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.

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. 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 area; and
- b) unless otherwise instructed, continue normal operations and:
 - 1) if one or more routes are affected by the area, suggest re-routings to the affected aircraft onto routes clear of the area; and
 - 2) maintain awareness of the affected area.

2.4. ATFM UNIT ACTIONS

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

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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 a 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 relevant AIS and MET messages in accordance with Annex 15 and Annex 3 respectively; 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 that 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, who should issue appropriate MET messages 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 and 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 a close liaison with the appropriate ATFM unit and the originating ACC to design, implement and keep up to date ATFM 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
- e) begin planning for the on-going eruption phase in conjunction with the aircraft operators, the appropriate ATFM unit and ACCs concerned.

3.4. ATFM UNIT ACTIONS

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. ON-GOING ERUPTION PHASE

4.1. The on-going eruption phase commences with the issuance of the first volcanic ash advisory (VAA) by the lead 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:

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- a) prepare appropriate AIS and MET messages in accordance with Annex 15 and Annex 3 provisions respectively; and
- b) 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 is 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 are originated 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 may take the initiative to organize teleconferences to exchange the 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 authorities (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 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 PROCEDURES

6.1 The following describes the actions in response to volcanic eruption to be taken by the ATM units charged with the provision of air traffic services in the NAT Region. It applies to both the High Seas and within sovereign airspace *except* to the extent that the States concerned may have decided otherwise for sovereign airspace. Experience has shown, that during the response actions, an imminent eruption can develop in to a full eruption of unexpected magnitude. It is therefore advisable to commence work in accordance with the *three actions* plan, already when an eruption is imminent, in order to keep full control of the situation. In a case when a situation of imminent eruption is prolonged, it is advantageous to protect a limited area

around the volcano and downwind from it, in order to be fully prepared when the eruption occurs. The Pre-eruption phase and the Start of eruption phase will therefore often merge.

6.2 PRE-ERUPTION PHASE

6.2.1 When an increased volcanic activity is reported and an eruption considered to be likely, a Danger Area of appropriate dimensions as determined by the appropriate authority will be established centred on the volcano or, if the wind direction is known and the wind strength warrants it a specified distance downwind.

6.3 START OF ERUPTION PHASE

6.3.1 *First action*

- a) When an eruption has started or is thought to be imminent, a Danger Area of appropriate dimensions as determined by the appropriate authority will be established centred on the volcano or, if the wind direction is known and the wind strength warrants it, a specified distance downwind. Traffic immediately affected will be offered the most expeditious route to escape the hazard. The establishment of the Danger Area will be announced by NOTAM, all traffic approaching the area will be routed around it. The MWO for the area in which the volcano is located will promulgate a SIGMET indicating the expected plume speed and direction of travel. ATM relays the SIGMET to affected aircraft. Adjacent ACCs will be informed.

6.3.2 *Second action.*

- a) As soon as possible after the first action, the MWO will predict, using all resources at its own disposal, the expected extent of the area of contamination and issue a SIGMET accordingly. This is intended to bridge the gap until the VAAC has had a chance to evaluate incoming data and take over the role of data analysis and promulgation. At this point ATM may cancel the Danger Area established around the volcano (or amend its dimensions). A NOTAM listing sources of information available to airspace users will be issued. ATM relays the SIGMET to affected aircraft.

6.3.3 *Third action.*

- a) The MWO starts routinely producing SIGMETs based on observations and VAAC data. ATM relays SIGMETs to affected aircraft. A Danger Area may be established (or continue to exist) around the volcano depending on circumstances and accommodates requests for re-routing or level changes to the extent practicable, suggest appropriate re-routing to the flight crew to avoid area of reported or forecast ash clouds when requested by the flight crew or deemed necessary by the controller;

6.4 ON-GOING ERUPTION PHASE

6.4.1 ATM performs the following actions:

- a) issues NOTAMs if significant changes in the magnitude of the eruption occur;
- b) relays SIGMETs to affected aircraft;
- c) relays Pilot Reports to other affected aircraft and the MWO;
- d) accommodates requests for re-routing or level changes to the extent practicable;

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- e) suggests appropriate re-routing to avoid or exit areas of reported or forecast ash clouds when requested by the pilot or deemed necessary by the controller;
- f) when practicable 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;
- g) provides Air Traffic Control services in a normal manner, including issuing reroute-, flight level change- and speed change clearances to aircraft operating or planning to operate inside areas contaminated with volcanic ash when required due to traffic. It is the responsibility of the pilot-in-command to determine if such clearances can be safely accepted or not; and
- h) imposes traffic flow restrictions as necessary to safely handle the air traffic taking especially into account:
 - 1) Anticipated amount of traffic;
 - 2) the expected dispersion of traffic due to individual airline decisions concerning penetration of contaminated areas;
 - 3) anticipated ATC workload due to mid-flight reroutes; and
 - 4) anticipated ATC workload in passing SIGMET information to aircraft.

Note 1.— Experience has shown that 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. The final responsibility for this decision, however, rests with the pilot-in-command as specified in the Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds (Doc 9691), 5.2.4.1.

Note 2.— The final authority as to the disposition of the aircraft, whether to avoid or proceed through a reported or forecast ash cloud, rests with the pilot-in-command, as prescribed in Annex 2, 2.4.

6.4.2 NAT OTS Design

- a) NAT Organized Tracks will normally not be established through areas forecast by the VAAC to be contaminated by volcanic ash. If Organized Tracks are established through contaminated areas, a note will be included on the NAT Track Message to identify such tracks..⁶

6.5 RECOVERY PHASE

6.5.1 When the eruption has ceased and no VA is observed or forecast a SIGMET declaring the airspace clear of Ash will be issued.

6.6 INADVERTENT ENTRY OF VOLCANIC ASH CLOUD

6.6.1 When the flight crew advises the ATS unit that the aircraft has inadvertently entered volcanic ash cloud, the ATS unit should:

⁶ Aircraft penetration into contaminated areas is based on specific safety assessments that are expected to vary between aircraft operators. Therefore, ATM cannot take these into account in the OTS design. Designing an OTS through a contaminated area may also falsely lead operators to believe that operation on a published track within the contaminated area has been deemed to be safe without an (operator-specific) safety assessment .

- a) take such action applicable to an aircraft in an emergency situation; and
- b) initiate modifications of route or level assigned only when requested by the pilot 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 DURING THE DEVELOPMENT OF AN ATM CONTINGENCY PLAN FOR VOLCANIC ASH

1. In a contingency plan relating to volcanic ash 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 aerodromes 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 crews and 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 may have consequences for the ATM system.

4. The area control centre (ACC) in conjunction with ATFM units 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 volcanic ash. Based on the information provided in SIGMET information for volcanic ash and volcanic ash advisories (VAAs), and working with MWOs, ATS personnel should be able to advise the flight crew of which flight levels are affected by the volcanic 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 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 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 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 the associated Volcanic Ash Advisory Centre (VAAC). NOTAM can also be used to limit access to the airspace affected by the volcanic ash. Complete guidance on the issuance of NOTAM 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 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 FLIGHT CREW 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;
- e) land at the nearest suitable aerodrome; and
- f) upon landing, thrust reversers 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:
 - 1) identify areas of concern;
 - 2) validate and improve volcanic ash forecasts;
 - 3) improve existing procedures;
 - 4) assist in defining better airworthiness requirements; and
 - 5) 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*

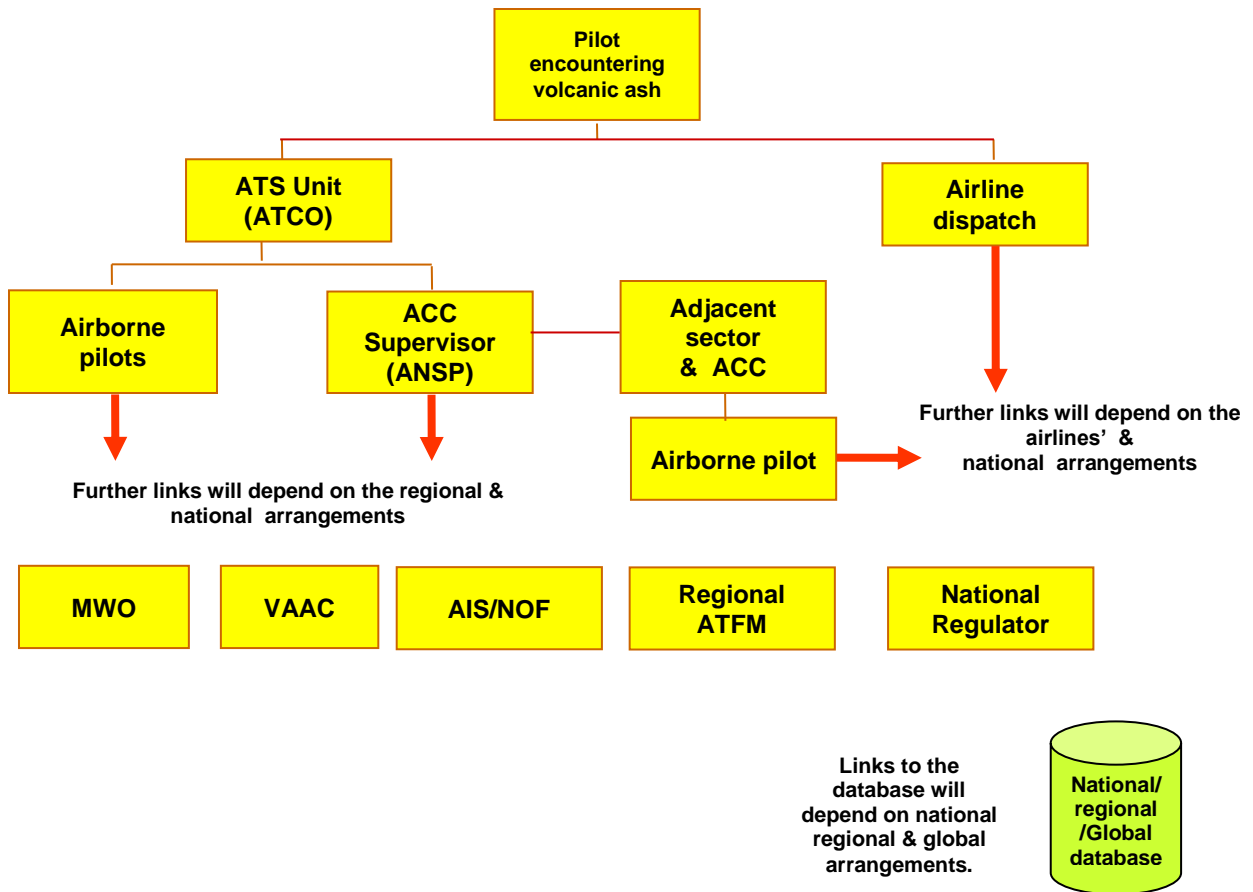
4.2.1 Participants, Roles & Responsibilities

	Participants	Roles & Responsibilities
	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.
	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.
	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 Europe); passed on to the national/regional authority responsible for the handling of contingency situations.
	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.
	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.
	VAAC	To use the information originated by flight crews, MWOs and other competent sources in accordance with Annex 3
	AIS / NOF	To publish appropriate AIS messages in accordance with Annex 15
	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; 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
- 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-atfcu>
- 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)

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