



**ADVANCE NOTICE OF PROPOSED AMENDMENT (A-NPA) No 2011-06**

**'Consultation on the ICAO IVATF paper about the management of flight operations  
with known or forecast volcanic cloud contamination'**

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## EXECUTIVE SUMMARY

1. The eruption of the Eyafjallajokull volcano in Iceland in April 2010 severely affected air traffic in Europe and globally. As a response to this event, ICAO created the International Volcanic Ash Task Force (IVATF) in July 2010 in order to assess the global aviation needs in relation to volcanic events.
2. One of the teams of the IVATF has developed a proposal for guidance material on the management of flight operations within known or forecast volcanic cloud contamination. This proposal is currently issued as draft version 4.
3. In the light of the issue of this draft version 4, the Agency has decided to issue the A-NPA with the purpose of:
  - a. supporting the ICAO International Volcanic Ash Task Force (IVATF) AIR team 04 by contributing to the consultation of draft version 4,
  - b. enabling European stakeholders to comment on the content of draft version 4, and
  - c. collecting stakeholders' feedback on the actions that should be implemented by the Agency following the outcome of the ICAO IVATF AIR 04 team work.

## A. EXPLANATORY NOTE

### I. General

1. The purpose of this Advance Notice of Proposed Amendment (A-NPA) is to provide European stakeholders with the opportunity to comment on the guidance material on the management of flight operations with known or forecast volcanic cloud contamination produced by the ICAO International Volcanic Ash Task Force (IVATF) AIR 04 team.
2. Additionally, this A-NPA has also the objective to collect stakeholders' advice on the actions that should be implemented by the Agency following the outcome of the ICAO IVATF AIR 04 team work, thereby helping to define how the current European regulatory context could benefit from such work.
3. The European Aviation Safety Agency (hereinafter referred to as the 'Agency') is directly involved in the rule-shaping process. It assists the Commission in its executive tasks by preparing draft regulations, and amendments thereof, for the implementation of the Basic Regulation<sup>1</sup> which are adopted as 'Opinions' (Article 19(1)). It also adopts Certification Specifications, including Airworthiness Codes and Acceptable Means of Compliance and Guidance Material to be used in the certification process (Article 19(2)).
4. When developing rules, the Agency is bound to follow a structured process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as 'The Rulemaking Procedure'<sup>2</sup>.
5. This rulemaking activity is included in the Agency's rulemaking programme for 2011. It implements the rulemaking task OPS.089.
6. The text of this A-NPA has been developed by the Agency. It is submitted for consultation of all interested parties in accordance with Article 52 of the Basic Regulation and Articles 5(3) and 6 of the Rulemaking Procedure.

### II. Consultation

7. To achieve optimal consultation, the Agency is publishing this A-NPA on its internet site. Comments should be provided within 28 days in accordance with Article 6(5) of the Rulemaking Procedure. Comments on this proposal should be submitted by one of the following methods:

**CRT:** Send your comments using the Comment-Response Tool (CRT) available at <http://hub.easa.europa.eu/crt/>

**E-mail:** In case the use of CRT is prevented by technical problems these should be reported to the [CRT webmaster](mailto:CRT_webmaster@easa.europa.eu) and comments should be sent by email to [NPA@easa.europa.eu](mailto:NPA@easa.europa.eu).

**Correspondence:** If you do not have access to internet or e-mail you can send your comment by mail to:

Process Support  
Rulemaking Directorate  
EASA  
Postfach 10 12 53  
D-50452 Cologne  
Germany

<sup>1</sup> Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1). Regulation as last amended by Commission Regulation (EC) 1108/2009 of the European Parliament and of the Council of 21 October 2009 (OJ L 309, 24.11.2009, p. 51).

<sup>2</sup> Management Board decision concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material (Rulemaking Procedure), EASA MB 08-2007, 13.6.2007.

Comments should be submitted by **30 May 2011**. If received after this deadline they might not be taken into account.

### **III. Comment response document**

8. All comments received in time will be considered. Comments made to Annex to this A-NPA will be consolidated and provided to the European Commission representative participating in the IVATF AIR 04 team, whereas the replies made to the questions included in section IV will be processed by the Agency.

### **IV. Content of the A-NPA**

#### ***Background***

9. The eruption of the Eyafjallajökull volcano in Iceland in April 2010 severely affected air traffic in Europe and globally. As a response to this event, ICAO created the International Volcanic Ash Task Force (IVATF) in July 2010 in order to assess the global aviation needs in relation with volcanic events.
10. The ICAO IVATF is a multidisciplinary group tasked to identify and propose actions to improve the global response to volcanic events. The work of the ICAO IVATF has been divided into several subgroups with expertise in different areas; in particular, the airworthiness subgroup (IVATF AIR) is focused on identifying unsafe factors, including airworthiness effects, for operations in volcanic ash.
11. As part of its work, the IVATF AIR 04 team has developed a Working Paper within which, at Attachment 1, there is material providing aircraft operators and the relevant National Aviation Authorities with guidelines to minimise the safety risk of flight operations in areas known or forecast to be affected by volcanic cloud.
12. This paper is currently issued as version 4 and it is open for consultation until the end of May 2011. Comments made to this version will lead to the production of the final version that will be presented by the IVATF AIR subgroup at the next IVATF meeting in Montreal in July 2011. Afterwards, the appropriate ICAO body will identify whether there is a need for amendment to the ICAO provisions or development of ICAO Standards and Recommended Practices (SARPs) or guidance material.
13. After the release of the final IVATF AIR 04 team paper in July several courses of action are possible. Member States will not be bound by any part of this document although they may consider that to some extent it should be taken into account. Consequently, in order to ensure a harmonised approach at European level, the Agency aims to identify which course of action would be the most adequate in the view of the European stakeholders and which measures should be implemented.
14. Therefore the Agency has decided to publish this A-NPA, which should serve to facilitate the consultation of the IVATF AIR 04 team document and to help deciding on the implementation of a future course of action.

#### ***Objectives***

15. Firstly, the Agency has the objective of supporting the work of the IVATF AIR 04 team, of which a European Commission representative is a member, by contributing to the consultation process referred to in paragraph 12 with the publication of the IVATF paper version 4 in the Annex to this A-NPA.
16. This initiative would allow European industry and national aviation authorities to contribute to the international effort with their comments on the contents of the version 4 of the paper. At the end of the consultation period, the Agency will consolidate the comments and provide them to the European Commission representative participating in the IVATF AIR 04 team. This would help identifying whether the document is aligned with the European stakeholders' expectations.

17. The second objective of this A-NPA is to define the course of action that the Agency should implement following the outcome of the work of the ICAO IVATF AIR 04 team. In order to help meet this objective, this A-NPA proposes a series of questions on which European industry and National Aviation Authorities are requested to express their views.
18. The answers to these questions will be consolidated in a document which should allow the Agency to identify the course of action and in particular: the need for a rulemaking initiative, the deliverable expected taking into account the European regulatory framework and the priority of such an initiative.

***The need for a rulemaking initiative***

19. In order to minimise the risk of flight operations in areas of known or forecast volcanic contamination, the ICAO IVATF AIR team 04 paper proposes an approach based on:
  - a. a risk assessment process for use by an operator wishing to conduct operations in areas of known or forecast volcanic contamination, and
  - b. an evaluation process for use by the operator's State in assessing whether or not the risk of that operation is minimised to an acceptable level by that operator's use of this process.
20. In the light of this paper, the views of the European stakeholders are important to determine whether, within the current European regulatory context, there is a need to develop requirements or guidance material in line with the IVATF proposal, and to that end whether a rulemaking task is required in order to ensure harmonisation at European Union level.
21. Alternatively, other views may consider that no action should be initiated until ICAO presents an amendment to Standards and Recommended Practices (SARPs) or develops specific guidance material.
22. Considering the above, the European stakeholders are requested to reply to the following question:

**Question 1: Which action do you consider the Agency should take following the conclusion of the work of the ICAO IVATF AIR team 04?**

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| <ol style="list-style-type: none"> <li>a) No immediate action is required. Wait until ICAO develops an amendment to Standards and Recommended Practices (SARPs) or guidance material.</li> <li>b) Initiate a rulemaking task to take into account the work of the ICAO IVATF AIR team 04 at European level.</li> <li>c) Other action. (Please go to question 4)</li> </ol> |
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23. If your answer to question 1 is option **b)**, then you are requested to answer questions 2 and 3 in order to help identifying the deliverable expected and the priority of the proposed task. Alternatively, if your answer to question 1 is **c)**, you are requested to answer only question 4.

***The deliverable expected***

24. When developing rules, the Agency is bound to follow a structured process as required in Article 52(1) of the Basic Regulation. As the result of this process, the Agency may:
  - a. submit an Opinion to the Commission proposing an amendment to the implementing rules which requires adoption by the European Parliament and the Council to become part of the European regulation, or
  - b. issue a Decision, which is adopted by the Agency's Executive Director, containing Certification Specifications, Acceptable Means of Compliance or Guidance Material reflecting best practices in the fields concerned.
25. The proposal contained in an Opinion becomes legally binding after its adoption, providing total harmonisation at implementation level, whereas decisions contain non-binding

material which helps implementing the regulation and is aimed at achieving certain level of harmonisation.

26. Therefore, should a rulemaking task be considered in question 1 as the action to be followed, it would be necessary to determine the deliverable expected of the task. For this reason, European stakeholders are requested to reply to the following question:

**Question 2: How should Attachment 1 to the ICAO IVATF AIR team 04 Working Paper be implemented in the European regulatory framework?**

- a) The content of the ICAO IVATF AIR team 04 paper should be included in a Decision and implemented as guidance material to the requirements for operators and National Aviation Authorities.
- b) An Opinion should be issued proposing an amendment to include specific requirements in the implementing rules for operators and National Aviation Authorities in line with the content of the ICAO IVATF AIR team 04 paper.
- c) The content of the ICAO IVATF AIR team 04 paper should be included partly in an Opinion and partly in a Decision. (Please specify in your reply which sections should be part of an Opinion and which should be Guidance Material.)

***The priority***

27. Whenever the need for a rulemaking task is identified, this should be included in the rulemaking programme and hence the estimated commencement should be established depending on the priority given to the particular task. In order to help establishing the priority of the proposed task, European stakeholders are required to reply to the following question:

**Question 3: What priority should be given to the proposed rulemaking task?**

- a) High priority; the task should start immediately after the conclusion of the work of the ICAO IVATF AIR team 04.
- b) Medium priority; the task should start in the next 2 years.
- c) Low priority; the commencement of the task could be delayed more than 2 years.

28. As regards the reply provided to question 1, European stakeholders may consider that initiatives other than or in addition to a rulemaking task could be implemented. In that case, they are required to reply to question 4:

**Question 4: Which action do you consider the Agency should take following the conclusion of the work of the ICAO IVATF AIR team 04?**

Please explain your recommendation including the priority and timeframe.

**V. Annex**

**1. IAVTF/2 – WP/**

/2011

**INTERNATIONAL VOLCANIC ASH TASK FORCE (IVATF)**

**SECOND MEETING**

*(Montreal, 11-15 July 2011)*

**Agenda Item XX: Report of the AIR 04 Team regarding the management of flight operations with known or forecast volcanic cloud contamination**

*(Presented by the IVATF AIR 04 Team)*

**SUMMARY**

This Working Paper sets out a proposal from the ICAO Volcanic Ash Task Force (IVATF) AIR 04 team for a process for aircraft operators and States to apply to the management of flight operations into, or avoiding, areas of known or forecast volcanic cloud.

This Paper recommends the adoption of the team's proposal, seeks formal confirmation that the team has completed its task and agreement to the disbandment of the team.

This Paper also provides findings covering issues identified by the team but for which potential solutions lie beyond the scope of the team's remit.

**1. Introduction**

- 1.1. The IVATF formed in July 2010 in response to the eruption of Eyjafjallajokull earlier that year. A review of lessons learned from that event revealed a gap in the extant material governing the arrangements for the management of flight operations in which volcanic cloud or ash is a hazard. Whilst much material was available in respect of the "detect and warn" aspects of managing such situations, no coherent material existed to cover the actions of the operator and any associated State activities.
- 1.2. The IVATF's AIR 04 Team was tasked with providing a proposal to remedy this gap.
- 1.3. This Working Paper sets out a proposal from the AIR 04 team for a process for aircraft operators and States to apply to the management of flight operations into, or avoiding, areas of known or forecast volcanic cloud.

- 1.4. This proposal is not intended to replace existing ICAO Annex 3 provisions covering the International Airways Volcano Watch (IAVW) system of oversight and production of warnings nor does it replace the guidance material provided under that system. The IVATF aims to provide new complementary guidance material to inform the further development and enhancement of the IAVW.

## **2. Discussion**

The AIR 04 team has generated a set of recommendations and findings. Recommendations herein refer to matters for which a broad consensus is in evidence whilst findings draw attention to matters requiring further work before a detailed recommendation can be clearly determined.

### **2.1 Recommendations**

- 2.1.1. The AIR 04 team's recommended approach is based on the premise that the operator is responsible for the safety of its operations.
- 2.1.2. The team recommends that the operator manage the safety of flight in situations where volcanic ash is a hazard in accordance with ICAO's Safety Management Systems approach; to this end, an identifiable Safety Risk Assessment for this hazard would exist within the operator's SMS. The team has also provided information on the preparation of an SRA to assist operators without an SMS.
- 2.1.3. The team emphasises that good quality information, correctly applied, is an essential foundation of a safe and effective operation. The team recommends that operators be encouraged to make use of all available information sources (e.g. forecasts or actual measurements) in assessing the hazard presented by volcanic contamination.
- 2.1.4. The team recommends that operators use a safety risk assessment approach in order to determine the appropriate restrictions to apply to where and when they will operate; the team has avoided setting such restrictions directly and; indeed, couches the SRA process in a manner that overtly contemplates flight into ash contaminated areas, as well as avoidance of such areas. To understand how this works, consider the current advice from aircraft and engine manufacturers that operators avoid flight in visible ash; each operator's safety risk assessment is bound by this restriction for so long as it remains current and, thus, the safety risk assessment process generates the required restriction to operations.

- 2.1.5. The team recommends that a State whose airspace contains actual or forecast ash contamination should allow operators from ICAO States access to such airspace without further investigation. To facilitate this approach, it is recommended that the evaluation of the competence of its operator to manage such operations and the robustness of the process used by the operator in making the related safety decisions be entrusted to the State with responsibility for the oversight of the operator.
- 2.1.6. Attachment 1 to this Working Paper sets out the practices and procedures that it is recommended operators and NAAs should adopt when managing flight operations in which ash is a hazard.

## 2.2 Findings

- 2.2.1. ICAO Doc 9691<sup>3</sup> acknowledges that there is, as yet, no agreement as to the ash concentration level that would constitute a hazard to aircraft engines. As a result, ICAO recommends that aircraft avoid exposure to volcanic ash, regardless of the ash concentration; latterly, this has been termed the avoidance of “visible ash”. The team believes that it is necessary and desirable that an appropriate value be agreed even if it is a conservative and generic value applicable to all aircraft. It is the AIR 04 team’s view that this is a gap in the current arrangements which would benefit from further development albeit that the task is outside the remit of the team.
- 2.2.2. As a consequence of the lack of clarity as to what level of ash constitutes an unsafe level, the team also noted that there was no clear specification from the aviation community to the VAACs as to the level of ash contamination to be depicted on VAAC products. Rather than the current undefined approach of delineating areas with “no ash”, the team felt that there was a need to delineate an area in which existed a significant risk of a substantive adverse safety outcome. The team has proposed that that outcome be an encounter with ash that was likely to render the aircraft unable to continue to, and land safely at, its intended destination or planned alternate. In the view of the AIR 04 team, this is a gap in the current arrangements which would benefit from further development albeit that the task is outside the remit of the team.
- 2.2.3. Even with these values defined, the team understands that, among VAACs, there may be differences, or at least a lack of a clear definition, of the process and considerations to be given effect in determining and delineating the airspace in which ash at the level of interest is likely to

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<sup>3</sup> ICAO *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds*, Second Edition — 2007

exist. The team believes that it would be valuable to operators if this information was available from VAACs in a globally consistent manner. In the view of the AIR 04 team, this is a gap in the current arrangements which would benefit from further development albeit that the task is outside the remit of the team.

- 2.2.4. Attachment 2 to this Working Paper sets out the work completed by the AIR 04 team in respect of recommended actions of pilots encountering an ash cloud. This work is within the direct remit of the AIR 05 team and, therefore, this material is to be remitted to them for further work. The team considers, however, that the resultant text should form part of the final set of information for operators in respect of it managing safety of flight where volcanic cloud is a hazard.

### 3. Actions

- 3.1 The AIR 04 team has completed its work and the following actions are proposed:

Action 2.xxxx	IVATF adoption of process for operator management of flight operations into, or avoiding, areas of known or forecast volcanic cloud
	That it be agreed that the proposal from the AIR 04 team merits adoption by ICAO.

Action 2.xxxx	Termination of AIR-04 task
	That it be agreed that AIR-04 group has completed the task given to it and that the team be disbanded.

- 3.2 To enable the work of the AIR 04 team to be adopted by ICAO, it is necessary to determine how the material should best be integrated into the wider body of related ICAO documentation and so the following action is proposed:

Action 2.xxxx	ICAO adoption of process for operator management of flight operations into, or avoiding, areas of known or forecast volcanic cloud
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	<p>That the Secretary be invited to review the recommended practices for flight operation procedures and incorporate those procedures in appropriate existing ICAO handbooks, manuals or procedures.</p>
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**2. IAVTF/2 – WP/ ATTACHMENT 1**

/2011

**INTERNATIONAL VOLCANIC ASH TASK FORCE (IVATF)**

**Report and recommendations from the IVATF AIR 04 Team regarding the management of flight operations with known or forecast volcanic cloud contamination.**

*(Presented by the IVATF AIR 04 Team)*

**SUMMARY**

The ICAO Volcanic Ash Task Force (IVATF) AIR 04 team has developed this proposal for a globally applicable process to facilitate the management of flight operations into, or avoiding, areas of known or forecast volcanic cloud through the provision of appropriate information to assist in minimising safety risk in such operations. The approach is based on a risk assessment process for use by an operator wishing to conduct such an operation and a process for use by that operator's State in evaluating the robustness of the process and the competence of the operator in using the process. It is intended that the State of the Operator or State of Registry, as appropriate, would make this determination on behalf of all other States through whose airspace the resultant flight operations are planned to be conducted.

- Draft Version 4.0-

**19 APRIL 2011**

THE DESIGNATIONS AND THE PRESENTATION OF MATERIAL IN THIS PUBLICATION DO NOT IMPLY THE EXPRESSION OF ANY OPINION WHATSOEVER ON THE PART OF ICAO CONCERNING THE LEGAL STATUS OF ANY COUNTRY, TERRITORY, CITY OR AREA OF ITS AUTHORITIES, OR CONCERNING THE DELIMITATION OF ITS FRONTIERS OR BOUNDARIES.

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## 1. DEFINITIONS

The terminology and acronyms used in this document are set out in Appendix H.

## 2. INTRODUCTION

There are areas of volcanic activity worldwide that are hazardous to aviation. Volcanic clouds can also be transported long distances into non-volcanic areas. This document sets out guidelines for aircraft operators, and the relevant National Aviation Authorities, to minimise the safety risk of flight operations in areas known or forecast to be affected by volcanic cloud. Health issues are not considered in this document nor are the detailed responsibilities of Type Certificate Holders set out.

### 2.1 The hazard

Volcanic ash<sup>4</sup> may cause:

- 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. Volcanic ash contains particles whose melting point is below engine burner temperature; these then fuse in the turbine section reducing the throat area and efficiency leading to engine surge and possibly flame-out;
- blockage of pitot and static sensors resulting in unreliable airspeed indications and erroneous warnings;
- windscreens to be rendered partially or completely opaque;
- smoke, dust and/or toxic chemical contamination of cabin air requiring crew use of oxygen masks, thus impacting communications;
- erosion of external aircraft components;
- reduced electronic cooling efficiency and, as ash readily absorbs water, potential short circuits leading to a wide range of aircraft system failures and anomalous behaviour;
- the aeroplane ventilation and pressurisation systems to become heavily contaminated. In particular, cleaning or replacement may be required in response to air cycle machine contamination and abrasion

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<sup>4</sup> Although the specific material being warned for is the ash contained in the volcanic cloud, it is understood that other elements of the cloud may also be undesirable to operate through and cause additional hazards

to rotating components, ozone converter contamination and air filter congestion.

- aircraft to be manoeuvred for ash avoidance in a manner that conflicts with other aircraft;
- deposits of volcanic ash on a runway degrading braking performance, especially if ash is wet; in extreme cases, this can lead to runway closure.

This list is not intended to be exhaustive.

## 2.2 Managing the risk

States that are required by Annexes 1, 6 (parts I or III), 11 or 14 to implement a State Safety Programme, are required to set an Acceptable Level of Safety for the relevant activities and to require all aviation Service Providers to implement a Safety Management System.

**NOTE:** It is proposed that the approach set out in this document be applied also to those engaged in international General Aviation as governed by Annex 6 Part II. The definition of an operator, set out in Appendix H, reflects this.

The principle of the operator having direct accountability for the safety of its operations is clearly defined in ICAO Annex 6. That Annex specifies an SMS as a key part of an operator's approach to exercising this accountability. ICAO Doc 9859 (Safety Management Manual) provides general guidance on the establishment of an SMS and on the conduct of a Safety Risk Assessment.

One of many issues requiring such an SMS approach relates to operations into or avoiding airspace with known or forecast volcanic cloud contamination or at aerodromes contaminated by volcanic ash. The operator is accountable for assessing the risk of such operations and for determining and implementing appropriate mitigation measures. This document describes an approach to formulating and evaluating the SRA central to this decision-making process.

Regulatory authorities of the State of the Operator or State of Registry, as appropriate, have an obligation to ensure that the operators they supervise are competent and capable of conducting a robust SRA and that the assessment process itself is robust. This present document sets out a process that NAAs may use in evaluating operator safety risk assessments.

It is further expected that the NAA should maintain adequate ongoing surveillance of the operator so that it can identify those operators who fail to maintain adequate competence, capability and robust procedures to

continue to operate safely into or avoiding volcanic cloud contamination; in such cases, it is expected that the NAA would take such action as may be necessary to control the risk associated with the operator's lack of competence, capability or necessary procedures.

The safety control measures set out in this document are intended to be sufficiently robust that a State whose airspace is known or forecast to be affected by volcanic clouds can, without further investigation, be confident in the ability of operators from other States to undertake operations safely in their airspace. Until such time as this approach has been widely accepted and implemented, however, it is recognised that States may wish to seek from a foreign operator, or from its State, positive confirmation of the satisfactory completion of an SRA.

### **2.3 Coordinating the response to a volcanic event**

There are many other contributors to the overall volcanic risk mitigation system such as Meteorological Watch Offices, Air Navigation Service Providers including Aeronautical Information Services, Meteorological Service providers, Volcanic Ash Advisory Centres, Volcano Observatories and aircraft and engine TCHs, STC holders and PMA holders. Their cooperation in supplying operators and NAAs with the information necessary to support the pre-flight SRA process and the in-flight and post-flight decision making process is essential to continuing safe operations.

Actions required of these contributors to provide for safe operations into, and avoiding, known and forecast volcanic ash cloud contaminated areas are set out in other ICAO documents such as:

- ICAO Procedures for Air Navigation Services (PANS) – Air Traffic Management (ICAO Doc 4444),
- ICAO Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds (ICAO Doc 9691),
- ICAO International Airways Volcano Watch (IAVW) Handbook (ICAO Doc 9766), and
- Regional contingency plans such as the EUR/NAT Contingency Plan (EUR Doc 019).

This present document, in addressing the role of the aircraft operator and of the operator's NAA, is complementary to the documents listed above. Relevant parts of these documents are under review by other subgroups of IVATF and amendment proposals are to be expected. In time, it is anticipated that ICAO will wish the guidance material to be consolidated.

To ensure good coordination between all concerned, it is recommended that operators and their NAAs participate in annual volcanic risk exercises normally organised by ICAO (VOLCEX). In the EUR and NAT region, for

example, information on these exercises is available on the ICAO Paris website <http://www.paris.icao.int/>.

### 3. RECOMMENDATIONS FOR THE AIRCRAFT OPERATOR

ICAO's generic safety risk assessment process is described in ICAO Doc 9859<sup>5</sup>. Alternative approaches, aligned with an organisation's approved SMS, would be equally appropriate. The material in this document is designed to support operators who have yet to implement an SMS covering the volcanic ash hazard.

#### 3.1 Responsibilities

- a) The operator is responsible for the safety of its operations.
- b) In order to decide whether or not to operate into, or avoid, airspace or aerodromes which may be contaminated by volcanic ash or volcanic clouds, the operator should have in place either a standalone SRA or an identifiable SRA within its SMS.

**NOTE:** Guidance on the production of an SRA is provided in Appendices A (guidelines on conducting an SRA), B (procedures to be included in an SRA) and C (risks to be considered). Each operator should develop its own list of procedures and hazards since these have to be relevant to the specific equipment, experience and knowledge of the operator, and to the routes to be flown.

- c) The operator should have its SRA accepted by its supervising NAA before initiating operations into or avoiding airspace or aerodromes, which may be contaminated by volcanic clouds or ash. The NAA may accept an SMS of which this SRA is an identifiable part.

**NOTE:** Subject to the provisions set out below regarding the updating of SRAs, it is intended that the operator should present the NAA with an SRA covering its overall operations in which volcanic clouds are a hazard rather than an SRA for each flight.

- d) An operator will need to have satisfied its NAA regarding the likely accuracy and quality of the information sources it uses in its SRA and its own competence and capability to interpret such data correctly in order to reliably and correctly resolve any conflicts among data sources that may arise.

**NOTE:** The operator is not prevented from operating through, or over, areas affected by a VAA, VAG or SIGMET provided it has demonstrated in its SRA the capability to do so safely.

- e) The operator should revise its SRA when changes that are material to the integrity of the SRA occur; it will need to inform its NAA of such updates in a timely manner.

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<sup>5</sup> ICAO *Safety Management Manual* (Section 9, Issue 2, 2009).

- f) The operator's SRA should take into account data published by the relevant TCHs regarding the susceptibility to volcanic cloud-related airworthiness effects of the aircraft they operate, the nature of these effects and the related pre-flight, in-flight and post-flight precautions to be observed by the operator.

**NOTE:** If no suitable information is available from the TCHs, then it is expected that the operator will constrain its risk assessment accordingly; it should then be assumed that the aircraft or engine has minimal tolerance to volcanic cloud exposure.

- g) The operator should ensure that those of its personnel needing to be familiar with the details of the SRA receive all relevant information (both pre-flight and in-flight) in order to be in a position to apply appropriate mitigation measures as specified by the SRA, especially when the situation deviates from any scenario contemplated in the SRA.
- h) The operator should ensure that any incidents related to volcanic clouds are reported immediately to the nearest ATS unit using the VAR/AIREP procedures followed up by a more detailed VAR on landing together with, as applicable, an ASR and AML entry.

### 3.2 Procedures

- a) The operator should have documented procedures for the management of operations into and around airspace, or at aerodromes, which may be contaminated by volcanic ash.

**NOTE:** Procedures should include crew action in the event that they encounter a volcanic cloud (the related material is being developed by the IVATF AIR 05 team).

**NOTE:** Procedures should include collaboration with ATM and aerodrome operators.

- b) These procedures should ensure that, at all times, flight operations remain within accepted safety boundaries despite any variations in information sources, equipment, operational experience or procedures. Procedures should include those for flight crew, flight planners, dispatchers, operations and maintenance personnel such that they are equipped to evaluate correctly the risk of flight into airspace contaminated by volcanic clouds and to plan accordingly.
- c) Engineering personnel should be provided with procedures allowing them to correctly assess the need for, and execute, relevant maintenance interventions.
- d) The operator will need to retain sufficient qualified and competent staff to generate well supported operational risk management decisions, and ensure that its staff are appropriately trained and current.

**NOTE:** It is not intended that the operator be precluded from securing necessary resources from other competent parties.

- e) The operator should encourage its flight operations staff to take up opportunities to be involved in volcanic ash exercises conducted in their region.

### **3.3 Information**

Before and during eruptions, information valuable to the operator is generated by various volcanological agencies worldwide. The operator's risk assessment and mitigating actions need to take account of, and respond appropriately to, the information likely to be available during each phase of the eruptive sequence from pre-eruption through to end of eruptive activity. Further material is provided in Appendix E.

## **4. RECOMMENDATIONS FOR THE NATIONAL AVIATION AUTHORITY**

ICAO's generic safety risk assessment process is described in the ICAO *Safety Management Manual* (Doc 9859 Section 9, Issue 2, 2009). Alternative approaches, aligned with an organisation's approved SMS, would be equally appropriate.

The operator-orientated responsibilities of the NAA of the State of Operator/Registry, and of States with known or forecast volcanic contamination, are indicated in Section 2.2 above.

The NAA overseeing an operator that intends to undertake operations into, or avoid, areas of known or forecast volcanic contamination should establish a methodology for evaluating the SRA of such an operator and, if satisfied, accept the SRA. The guidance set out in Appendix F indicates a process that the NAA can use to achieve this outcome.

## APPENDIX A

### GUIDELINES FOR COMPLETING A SAFETY RISK ASSESSMENT

#### A1 Introduction

ICAO's generic safety risk assessment process is described in the ICAO *Safety Management Manual* (Doc 9859 Section 9, Issue 2, 2009). Alternative approaches, aligned with an organisation's approved SMS, would be equally appropriate.

This Appendix is designed to support operators who have yet to implement an SMS covering the volcanic ash hazard.

Risk is an assessment of the likelihood and severity of adverse consequences resulting from a hazard. To help an operator to decide on the likelihood of a hazard causing harm, and to assist with possible mitigation of any perceived safety risk, all pertinent information available should be taken into account and relevant stakeholders consulted.

The safety risk from each hazard should be assessed using a suitable safety risk register. The safety risk should be derived by considering the severity of the safety risk outcome arising from the hazard, together with the likelihood of that outcome.

The severity of any adverse consequences resulting from a particular hazard should be assessed using a suitable severity scale.

#### A2 The Process Steps

When made specific to the issue of intended flight into, or avoiding, known or forecast volcanic ash contaminated airspace or aerodromes, then the process involves:

- Identifying the hazard (i.e. arising from the generic hazard of airspace or aerodromes with known or forecast contamination by volcanic ash with characteristics harmful to the airworthiness and operation of the aircraft);
- Considering the seriousness of the hazard occurring (i.e. the actual level of damage expected to be inflicted on the particular aircraft from exposure to that volcanic ash);
- Evaluating the likelihood of encountering ash with characteristics harmful to the safe operation of the aircraft;
- Determining whether the consequent risk is acceptable and within the organisation's risk performance criteria;
- Taking action to reduce the safety risk to a level that is acceptable to the operator's Accountable Executive or equivalent.

## **A2.1 Hazard Identification**

The generic hazard, in the context of this document, is airspace or aerodromes with known or forecast contamination by a volcanic ash cloud with characteristics harmful to the airworthiness and operation of the aircraft.

Within this generic hazard is the specific hazard of an operator not having secured the information necessary to properly characterise that hazard and develop a robust assessment of the risk and likely success of any chosen mitigating actions. To assist operators in relation to this specific hazard, guidance on the list of procedures to be considered is given in Appendix B.

A list of suggested hazards and their associated risks is provided in Appendix C.

Neither of these lists is exhaustive; the operator should develop its own taking into account its specific equipment, experience, knowledge and type of operation.

## **A2.2 Risk Severity**

For each hazard, the potential adverse consequences or outcome should be assessed. Again, the results of this phase of the assessment should be recorded in a risk register, such as that reproduced at Appendix D.

## **A2.3 Risk Likelihood**

For each hazard, the likelihood of adverse consequences should be assessed, either qualitatively or quantitatively, using a suitably calibrated likelihood scale. When assessing likelihood, the following factors should be taken into account:

- Any uncertainties in available information;
- The duration of exposure to the hazard and associated severity;
- Any historic incident or safety event data relating to the hazard. This can be derived using data from TCHs, regulators, other operators, Air Navigation Service Providers, internal reports etc;
- The expert judgement of relevant stakeholders notably from TCHs.
- Operational environment in which flight operations are performed.

The results of this phase of the assessment should be recorded in a risk register, an example of which is at Appendix D.

## **A2.4 Risk Tolerability**

At this stage of the process, the safety risks should be classified acceptable or unacceptable.

It is recognised that the assessment of tolerability will be subjective based on qualitative data and expert judgement until specific quantitative data is available in respect of a range of parameters such as uncertainty in ash forecast accuracy, the likely range of engine tolerability to ash ingestion with time and engine condition etc.

Appropriate mitigations for each unacceptable risk identified should then be considered, recorded on the risk register and implemented in order to reduce the risks to a level acceptable to the operator's Accountable Executive or equivalent.

Not all risks can be suitably mitigated; in such cases, the operation should not proceed.

### **A2.5 Mitigating Actions**

Mitigating actions by themselves can introduce new risks. Where an organisation has an effective SMS, procedures should exist for continuous monitoring of hazards and risk, with qualified personnel establishing the mitigating actions or halting affected operations.

Given the potential introduction of new risks, or of circumstances on which the original assessment was predicated changing, an operator without an effective SMS, should repeat the safety risk assessment following any mitigation process and at regular intervals.

### **A3 Records**

The results of the safety risk assessment should be documented and submitted to the operator's NAA. Mitigating actions should be completed and verified and supported by evidence prior to the start of operations.

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

**NOTE: Any safety performance monitoring requirements should also be identified and undertaken through the organisation's safety risk management processes.**

**NOTE:** The SMS material of ICAO Doc 9859 continues to be developed within the ICAO ISM section and this team's expert assessment of this Appendix and associated material will be sought as part of the process of considering the Guidance Material for formal ICAO adoption.

**APPENDIX B****PROCEDURES TO BE CONSIDERED BY AN AIRCRAFT OPERATOR  
WHEN CONDUCTING A SAFETY RISK ASSESSMENT**

Considerations	Actions
<b>Preparation</b>	
Type Certificate Holder	<p>The operator will need to obtain advice from the TCHs of the aircraft it operates concerning operations in potentially contaminated airspace and/or to/from aerodromes contaminated by volcanic ash. This advice should set out:</p> <ul style="list-style-type: none"> <li>– the features of the aircraft that are susceptible to airworthiness effects related to volcanic ash;</li> <li>– the nature and severity of these effects ;</li> <li>– the effect of volcanic ash on operations to/from contaminated aerodromes;</li> <li>– the related pre-flight, in-flight and post-flight precautions to be observed by the operator</li> <li>– the recommended continuing airworthiness inspections associated with operations in volcanic ash contaminated airspace and to/from volcanic ash contaminated aerodromes.</li> </ul>
Operator Personnel or their Service Providers	<p>The operator should publish procedures for flight planning, operations and maintenance ensuring that:</p> <ul style="list-style-type: none"> <li>– flight planners, operations staff and dispatchers are equipped to evaluate correctly the risk of flight into volcanic ash-contaminated airspace, or aerodromes, and can plan accordingly;</li> <li>– flight planning and operational procedures enable crews to avoid areas and aerodromes with unacceptable volcanic ash contamination levels;</li> <li>– flight crew can detect volcanic ash and execute the associated escape manoeuvres;</li> <li>– engineering personnel are able to assess the need for, and to execute, any necessary maintenance interventions.</li> </ul>

Considerations	Actions
<b>Operator procedures</b>	
Provision of Enhanced Flight Watch	<p>The operator will need to:</p> <ul style="list-style-type: none"> <li>– closely and continuously monitor VAA, VAR/AIREP, SIGMET, NOTAM and ASHTAM information, and information from its crews, concerning the volcanic ash cloud hazard;</li> <li>– ensure that its Operations Unit, or equivalent, and its crews, have access to plots of the affected area from SIGMETs and NOTAMs;</li> <li>– ensure that the latest information is communicated to its crews and planners in a timely fashion.</li> </ul>
Flight Planning	<p>The operator will need to plan flights to remain clear of areas with a volcanic ash contamination level beyond that for which it has developed an SRA accepted by its NAA. The operator's process should be sufficiently flexible to allow re-planning at short notice should conditions change.</p>
Departure, Destination and Alternates	<p>For the airspace to be traversed, or the aerodromes in use, the operator should determine, and take account of:</p> <ul style="list-style-type: none"> <li>– the degree of known or forecast contamination;</li> <li>– any additional aircraft performance requirements;</li> <li>– required maintenance considerations;</li> <li>– fuel requirements for re-routeing and extended holding.</li> </ul>
Routeing Policy	<p>The operator should determine, and take account of,;</p> <ul style="list-style-type: none"> <li>– the shortest period in and over the contaminated area;</li> <li>– the hazards associated with flying over the contaminated area;</li> <li>– drift down and emergency descent considerations.</li> </ul>
Diversion Policy	<p>The operator should determine, and take account of:</p> <ul style="list-style-type: none"> <li>– maximum allowed distance from a suitable alternate;</li> <li>– availability of alternates outside contaminated area;</li> <li>– diversion policy after an volcanic ash encounter.</li> </ul>
Minimum Equipment List / Dispatch Deviation Guide	<p>The operator should consider additional restrictions for dispatching aircraft with unserviceabilities which might affect:</p> <ul style="list-style-type: none"> <li>– air conditioning packs;</li> <li>– engine bleeds;</li> <li>– pressurisation system</li> <li>– electrical power distribution system</li> <li>– air data computers;</li> <li>– standby instruments;</li> <li>– navigation systems;</li> <li>– de-icing systems;</li> <li>– engine driven generators;</li> <li>– Auxiliary Power Unit (APU);</li> <li>– Airborne Collision Avoidance System (ACAS);</li> <li>– Terrain Awareness Warning System (TAWS);</li> <li>– Autoland systems;</li> </ul>

	<ul style="list-style-type: none"> <li>- provision of crew oxygen; and</li> <li>- supplemental oxygen for passengers.</li> </ul> <p style="text-align: center;">(This list is not exhaustive)</p>
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Considerations	Actions
<b>Flight Crew Procedures</b>	
Standard Operating Procedures	<p>The operator should ensure that crews review normal and abnormal operating procedures and particularly any changes regarding:</p> <ul style="list-style-type: none"> <li>- pre-flight planning;</li> <li>- in-flight monitoring of volcanic cloud affected areas and avoidance procedures;</li> <li>- diversion policy;</li> <li>- communications with ATC;</li> <li>- in-flight monitoring of engine and systems potentially affected by volcanic ash contamination;</li> <li>- recognition and detection of volcanic ash clouds.</li> <li>- in-flight indications of a volcanic cloud encounter;</li> <li>- procedures to be followed if a volcanic cloud is encountered;</li> <li>- unreliable erroneous airspeed;</li> <li>- non-normal procedures for engines and systems potentially affected by volcanic ash contamination;</li> <li>- engine-out and engine relight;</li> <li>- escape routes; and</li> <li>- operations to/from aerodromes contaminated with volcanic ash.</li> </ul> <p style="text-align: center;">(This list is not exhaustive)</p> <p><b>NOTE:</b> In promulgating changes to SOPs, it is anticipated that the normal practice of the operator will be to not only ensure appropriate briefing of these changes but also to ensure that any necessary training is completed.</p>
AML	<p>The operator should ensure that crews:</p> <ul style="list-style-type: none"> <li>- make an AML entry for each operation to or from an aerodrome which may be contaminated;</li> <li>- make an AML entry related to any actual or suspected volcanic ash encounter;</li> <li>- confirm, prior to flight, completion of maintenance actions related to an AML entry for a volcanic ash encounter on a previous flight.</li> </ul>
Incident Reporting	<p>The operator should specify crew requirements for:</p> <ul style="list-style-type: none"> <li>- reporting an airborne volcanic cloud encounter (VAR);</li> <li>- post-flight volcanic cloud reporting (VAR);</li> <li>- filing a mandatory occurrence report as required by the State.</li> </ul>

Considerations	Actions
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<b>Maintenance Procedures</b>	
Maintenance Procedures	<p>An operator operating in, or near, areas of volcanic ash contamination, should:</p> <ul style="list-style-type: none"> <li>– enhance vigilance during inspections and regular maintenance and make appropriate adjustments to maintenance practices;</li> <li>– have produced a continuing airworthiness procedure to follow when a volcanic ash encounter has been reported or suspected;</li> <li>– ensure that a thorough investigation is carried out of any signs of unusual or accelerated abrasions or corrosion or of volcanic ash accumulation;</li> <li>– co-operate in reporting to TCHs and the relevant authorities their observations and experiences from operations in areas of volcanic ash contamination;</li> <li>– comply with any additional maintenance recommended by the TCH.</li> </ul>

**Note:** The above list is not exhaustive; the operator will need to develop its own list taking into account its specific equipment, experience, knowledge and type of operation.

## APPENDIX C

**RISKS TO BE CONSIDERED BY AN AIRCRAFT OPERATOR  
WHEN CONDUCTING A SAFETY RISK ASSESSMENT**

Activity or Issue	Hazard	Risk
<i>Flight Planning</i>		
Lack of awareness, or incorrect interpretation, of regulations or restrictions mandated by the Authorities of the State in which the airspace or aerodromes are known or forecast to be contaminated by volcanic clouds	Safety restrictions imposed, or safety requirements defined, by the Authorities not correctly incorporated into the flight planning process	Inadvertent volcanic ash encounter with adverse safety consequences
Lack of awareness, or incorrect interpretation, of volcanic ash concentration information provided to Operator's flight planners	Volcanic ash concentration data not correctly incorporated into the flight planning process	Inadvertent volcanic ash encounter with adverse safety consequences
Lack of awareness, or incorrect interpretation, of volcanic ash concentration information provided to crews at pre-flight briefing	Crews unaware of correct extent, concentration and position of volcanic clouds	Inadvertent volcanic ash encounter with adverse safety consequences
Incorrect, or misunderstood, information regarding status of aircraft away from base	Aircraft no longer in compliance with airworthiness requirements	Operation by aircraft not legally authorized to operate
	Aircraft in unsafe condition for flight	Serious incident or accident
Incorrect, or misunderstood, information regarding status of crew away from base	Crew out of compliance or recency	Operation with crew not legally authorized to operate, crew mishandle aircraft or inadvertent ash encounter with adverse safety consequences
Ground equipment in temporary storage state	Equipment not operating as designed or intended following temporary storage	Adverse safety consequences dependent on equipment concerned
etc		

Activity or Issue	Hazard	Potential Outcome
<i>In-flight (volcanic cloud avoidance)</i>		
Communication of volcanic cloud movement to crews in-flight	Crews unaware of the position or extent of the volcanic ash-contaminated area	Inadvertent volcanic cloud encounter with adverse safety consequences
Change in location of volcanic ash-affected area that incorporates an area in which an aircraft is flying	Crews unaware of the change of position or extent of the volcanic ash-contaminated area	Inadvertent volcanic cloud encounter with adverse safety consequences
Provision of graphical data to crews	Crews unaware of the position or extent of the volcanic ash-contaminated area	Inadvertent volcanic cloud encounter with adverse safety consequences
etc		
<i>In-flight (inadvertent volcanic cloud encounter)</i>		
Pitot and probe blockage	<ul style="list-style-type: none"> <li>– Unreliable, or erroneous, airspeed</li> <li>– Aircraft control problems</li> <li>– Thrust control reduced</li> </ul>	Loss of control
Window abrasion	<ul style="list-style-type: none"> <li>– Restricted external vision</li> <li>– Loss of visual reference</li> </ul>	Loss of control / runway excursion
Turbine and compressor damage	<ul style="list-style-type: none"> <li>– Anomalous engine behaviour</li> <li>– Loss of thrust: single engine</li> <li>– Loss of thrust: all engines</li> </ul>	<ul style="list-style-type: none"> <li>– Increased crew workload</li> <li>– Diversion</li> <li>– Forced landing</li> </ul>
Fuel Contamination	Loss of thrust: all engines	Forced landing
Air-conditioning Pack volcanic cloud ingestion	<ul style="list-style-type: none"> <li>– Loss of cabin pressurisation</li> <li>– Noxious fumes in cabin</li> </ul>	Emergency descent / Diversion / Loss of control
Equipment Cooling Failure due volcanic cloud ingestion	Anomalous behaviour of aircraft systems	<ul style="list-style-type: none"> <li>– Increased crew workload</li> <li>– Diversion</li> <li>– Forced landing</li> <li>– Loss of control</li> </ul>
Volcanic cloud static charge	Prolonged loss of communications	<ul style="list-style-type: none"> <li>– Increased crew workload</li> <li>– Increased ATC workload</li> </ul>
Escape Manoeuvre	Conflict with another aircraft	Mid air collision

etc		
<b>Post-flight</b>		
Failure to report an volcanic cloud encounter	Unreported damage	Aircraft departs in an un-airworthy state
	Operator, MWO, VAAC and ATC not aware of the position height or extent of volcanic ash	Other aircraft encounter volcanic clouds
etc		

**Note:** The above list is not exhaustive; the operator will need to develop its own list taking into account its specific equipment, experience, knowledge and type of operation.

### Appendix D

#### Example of a Risk Register

No	Hazard Description	Hazard Consequence Description	Existing Controls	Outcome (Pre-Mitigation)			Further Actions to Reduce Risk	Outcome (Post-Mitigation)			Risk Owners	Monitoring and Review Actions
				Severity	Likelihood	Risk Tolerability		Severity	Likelihood	Risk Tolerability		
1	Flying into area of volcanic ash	Loss of thrust – all engines	Avoidance, existing crew procedures	High	Remote	Un-acceptable	Monitoring of NOTAMs, Flight planning to avoid flying into Danger Area, QRH drills for volcanic ash procedures, Notice to crew on in-flight volcanic ash encounters	High	Extremely Remote	Review	Flight Operations	Ensure latest information available to crew. Monitoring of pilot reports and review of revised flight planning and operating procedures
2	Flying into area of volcanic ash	Damage to windscreen obscuring vision	Avoidance, existing crew procedures	Medium	Remote	Un-acceptable	Monitoring of NOTAMs, Flight planning to avoid flying danger Area, QRH drill for volcanic ash procedures, Notice to crew on in-flight volcanic ash encounters	Medium	Extremely Remote	Acceptable	Flight Operations	Ensure latest information available to crew. Monitoring of pilot reports and review of revised flight planning and operating procedures
3	Flying into or close to area of volcanic ash	Undetected engine and airframe damage leading to system or component failure	Pre-flight checks and walk-around checks, Scheduled maintenance	Medium	Possible	Un-acceptable	Enhanced reporting and flight tracking for flights into or close to Danger Area. Additional inspections of ash contamination iaw TCH Instructions	Medium	Extremely Remote	Acceptable	Operations, Engineering	Monitoring of enhanced reporting system and engineering inspections
4												
5												

## APPENDIX E

### GUIDELINES ON VOLCANIC ACTIVITY INFORMATION AND OPERATOR RESPONSE

#### E.1 Overview

The material set out in this Appendix is intended to inform the operator about the range of volcanic activity information that may be available during an eruptive cycle and to indicate the operator's potential response. It is noted that eruptions rarely follow a deterministic pattern of behaviour.

#### E.2 Pre-Eruption

- a) The operator should have in place a robust mechanism for ensuring that it is constantly vigilant for any alerts of pre-eruption volcanic activity relevant to its operations. The staff involved need to understand the threat to safe operations that such alerts represent; some operators include this expertise within their "Operations Unit".
- b) An operator whose routes traverse large, active volcanic areas for which immediate IAVW alerts may not be available, should define its strategy for capturing information about increased volcanic activity before pre-eruption alerts are generated.<sup>6</sup> Such an operator should also ensure that its crews are aware that they may be the first to observe an eruption and so need to be vigilant and ready to ensure that this information is made available for wider dissemination as quickly as possible.

#### E.3 Start of an Eruption

- a) Given the likely uncertainty regarding the status of the eruption during the early stages of an event and regarding the associated volcanic cloud, the operator's procedures should include a requirement for crews to initiate or accept re-routes to avoid the affected airspace.
- b) The operator should ensure that flights are planned to remain clear of the affected area and that consideration is given to available alternate aerodromes and fuel requirements.
- c) It is expected that following initial actions will be taken:
  - Alert management;
  - Determine if any aircraft in flight could be affected, alerting the crew and re-routing as required;

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<sup>6</sup> For example, an operator may combine elevated activity information with information concerning the profile and history of the volcano to determine an operating policy, which could include re-routing or restrictions at night. This would be useful when dealing with the 60% of volcanoes which are unmonitored.

- Brief flight crew and revise flight and fuel planning in accordance with the SRA;
- Alert flight crew and operations staff to the need for increased monitoring of AIREP/VARs, SIGMETs and NOTAMs;
- Initiate the gathering of all data relevant to determining the risk;

**NOTE:** If the appropriate ATFM Unit organises regular data sharing teleconferences, the operator should make arrangements to participate

- Apply mitigations identified in the SRA process.

#### **E.4 Ongoing Eruption**

- a) As the eruptive event develops, the operator can expect the responsible VAAC to provide VAA/VAGs defining, as accurately as possible, the vertical and horizontal extent of areas and layers of volcanic clouds. As a minimum, the operator should monitor, and take account of, this VAAC information as well as of relevant SIGMETs and NOTAMs.
- b) Other sources of information are likely to be available such as VAR/AIREPs, satellite imagery and a range of other information from State and commercial organisations<sup>7</sup>. The operator should plan its operations in accordance with its SRA taking into account also those of these additional sources of information that it considers accurate and relevant.
- c) The operator will have to resolve, reliably and correctly, any differences or conflicts among the information sources, notably between published information and observations (pilot reports, airborne measurements, etc.); the operator should, as soon as possible, report such discrepancies to the appropriate authorities including the responsible VAAC and MWO.
- d) Given the dynamic nature of the volcanic hazards, the operator should ensure that the situation is monitored closely and operations adjusted to suit.
- e) The operator should be aware that, depending on the State concerned:
  - i. Affected Areas or Danger Areas may be established that differentiate between various levels of volcanic ash contamination such as the Low, Medium and High contamination thresholds currently being used in Europe;

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<sup>7</sup> In the US, operators holding Enhanced Weather Information System (EWINS) approval are authorized to produce flight movement forecasts, adverse weather phenomena forecasts and other meteorological advisories, including those related to ash contamination, based on meteorological observations provided by the State.

- ii. Affected Areas or Danger Areas may be established covering airspace containing volcanic ash regardless of the contamination level. If no graduation of the volcanic ash contamination is given, operators should treat the whole area as if it contains High volcanic ash contamination, unless the operator's SRA allows it to do otherwise safely.
- f) The operator should require reports from its crews operating in or close to areas affected, concerning any encounters with volcanic emissions, and ATC requirements. These reports should be passed immediately to the responsible VAAC and MWO.
- g) For the purpose of flight planning, the operator should treat the horizontal and vertical limits of the Danger Area to be over-flown as they would mountainous terrain, modified in accordance with their SRA. The operator will need to take account of the risk of cabin depressurisation or engine failure resulting in the inability to maintain level flight above a volcanic cloud, especially when conducting ETOPS operations. Additional MEL restrictions should be considered in consultation with the TCHs.
- h) When the airspace is no longer contaminated by volcanic ash, a NOTAMC cancelling the active NOTAM is likely to be promulgated. A new NOTAM/ASHTAM would then be promulgated to update the situation.

## APPENDIX F

### GUIDELINES FOR NAAs ON EVALUATING AN OPERATOR'S CAPABILITY TO CONDUCT FLIGHTS SAFELY IN RELATION TO VOLCANIC CLOUD

#### F.1 Procedures

- a) The aim of these guidelines is to assist the NAA of the State of Registry/Operator in its oversight of an operator intending to undertake operations into, or avoid, areas with known or forecast volcanic cloud contamination where the NAA has chosen to follow an SRA approach.
- b) Prior to the planned operation, the NAA will need to be satisfied that the operator has completed an SRA relevant to its type of operation and acceptable to the NAA.

**NOTE:** The significance of the NAA accepting, rather than approving, an SRA is that the operator clearly retains responsibility for managing the risks and mitigating measures.

**NOTE:** Should the operator include the SRA for this hazard within its SMS, then the NAA may choose to accept an SMS of which this SRA is an identifiable part.

- c) The objective of the SRA is to provide a formal, robust and transparent method by which the operator can demonstrate to the NAA that it has the capability and competence to achieve a safe outcome from flight operations into, or avoiding, areas with known or forecast volcanic cloud contamination.
- d) The NAA's acceptance of the SRA should be dependent on a satisfactory confirmation by the operator of its competence and capability to:
  - understand the hazards associated with volcanic ash and its affect on the equipment being operated;
  - be clear on where these hazards may exceed acceptable safety risk limits;

**NOTE:** It is assumed that acceptable safety risk limits are exceeded when there is no longer a high level of confidence that the aircraft can continue to its intended destination or a planned alternate.

- identify and implement mitigations including suspension of operations where mitigation cannot reduce the risk to within safety risk limits;

**NOTE:** This assessment is generally recorded in a formal Risk Register (example at appendix D).

- develop, and execute effectively, robust procedures for planning and operating flights through, or avoiding, potentially contaminated airspace safely;
- choose correctly information sources to use, to interpret the information correctly and to resolve correctly any conflicts among such sources;
- take account of detailed information from its TCHs concerning volcanic ash-related airworthiness aspects of the aircraft it operates, and the related pre-flight, in-flight and post-flight precautions to be observed;
- assess the competence and currency of its staff in relation to the duties necessary to operate safely in, or avoid, areas of known or forecast volcanic ash contamination and to implement any necessary training;
- retain sufficient numbers of qualified and competent staff for such duties

**NOTE:** It is not intended that the operator be precluded from securing necessary resources from other competent parties.

e) The NAA should consider:

- those of the operator's recorded mitigations of most significance to a safe outcome are in place;
- those of the operational procedures specified by the operator with the most significance to safety appear to be robust;
- that the staff on which the operator depends in respect of those duties necessary to operate safely in, or avoid, areas of known or forecast volcanic ash contamination are trained and assessed as competent in the relevant procedures.

f) An analysis of the output of the operator's Safety and Risk Assessment allows the NAA to review its Hazard Analysis competency and Safety Culture in a coherent way, and provide an indication of the degree of confidence. An example of one approach to a Safety and Risk Assessment Matrix is given at Appendix G to guide NAAs through the process of evaluating operator Safety Risk Assessments. It is acknowledged that each NAA may modify this document to fit their SMS approach. It is acknowledged that the nature of this assessment is such that it does not lend itself to a substantive quantitative approach though such an approach would be welcome in due course.

g) As part of its regular oversight of the operator, the NAA should remain satisfied as to the continuing validity of an SRA accepted for operations into or avoiding volcanic cloud contamination;

**NOTE:** Should an operator fail to maintain an acceptable SRA, and associated resources, knowledge and procedures, the NAA should withdraw its acceptance of the SRA in order to prohibit such operations

## **F.2 Capabilities**

- a) The NAA will need to have a thorough understanding of SRA principles and methodology.
- b) The NAA will need to have the means to impose such restrictions on its operators as are necessary to minimise the volcanic ash safety risk.
- c) The NAA should strongly encourage those of its staff involved in evaluating operator SRAs to take up any opportunity to be involved in such VOLCEX exercises as are conducted in their region.
- d) Where an NAA considers that it lacks the capability to assess an operator's SRA, it should enlist the assistance of an NAA with this capability.

**APPENDIX G**

**EXAMPLE OF A SAFETY AND RISK ASSESSMENT MATRIX**

**THE OPERATION**

<b>Operator</b>	
<b>AOC No</b>	
<b>Aircraft Type(s)</b>	
<b>Engines</b>	
<b>No of aircraft</b>	
<b>Zones of Operation</b>	

**AUTHORISATION**

Any "NO" rating should cause the NAA to with-hold and withdraw acceptance of the SRA

<b>Has the operator satisfactorily demonstrated:</b>	Adequate understanding of the nature and location of the hazards?	<b>YES/NO</b>
	Clarity as to its safety risk limits?	<b>YES/NO</b>
	Robust documented procedures to ensure that the operation stays within limits?	<b>YES/NO</b>
	Adequate competence and capability to reliably execute its documented procedures on an on-going basis?	<b>YES/NO</b>
<b>Has this demonstration been documented by the operator?</b>		<b>YES/NO</b>
<b>Authorisation</b>	Has the SRA been accepted thus signifying that the NAA is satisfied that the operator can operate, in accordance with its procedures, into areas of known or forecast contamination by volcanic material?	<b>YES/NO</b>

**EVALUATION**

Any "unacceptable" elements in should result in operational restrictions up to and including prohibition or suspension of operations. Any "acceptable" elements could indicate an increased likelihood of failing to sustain acceptable standards and should result in the NAA enhancing its operator surveillance accordingly.

Factor	Evaluated As			Notes
	<u>Unacceptable</u>	<u>Acceptable</u>	<u>Best Practice</u>	
Safety Policy	No policy in place, or poorly developed/ inappropriate	An appropriate safety policy is in place	Management commitment to the safety policy is evident in all that the operator does	
	No evidence of commitment to/ action in line with the policy	The policy is linked to other company practices/activities	Safety is integral to business improvement in all relevant aspects of the operator's activity	
	Policy has not been approved at senior management level nor communicated effectively to staff	Policy has been approved and promulgated by senior management and is understood by all staff	Evidence that the policy has been approved and promulgated by senior management, is understood by all staff <u>and</u> staff understand and act on the policy in day to day business	

<b>Understanding Risks</b>	Operating procedures and practices do not reflect adequately the risks and hazards from this kind of activity	Operating procedures and practices reflect adequately the known risks/hazards of this type of activity	Evidence that the procedures and practices reflect well the known risks/hazards of this type of activity <u>and</u> the operator is proactive in receiving and sharing information regarding relevant risks/hazards with aviation community	
	No particular effort made to identify or assess hazards/risks specific to this particular operation	An adequate Hazard identification and prioritisation carried out for this specific operation	Clear evidence of a regular review and update of hazard/risk assessment in light of own and others' experience	
	No documented picture of risks/ hazards faced ("Safety Risk Profile")	Documented Safety Risk Profile is in place	Staff understand the Safety Risk Profile and demonstrate commitment to their part in risk control	
	Own experience not factored into any documented picture of risks/ hazards the operator faces	Own incident & occurrence experience is factored into picture of risks/hazards faced	Leaders in understanding of relevant risks, based on own knowledge and evidence from elsewhere	

**APPENDIX H****TERMINOLOGY****H.1 Acronyms**

AIREP	Special Air Report - a message from an in-flight aircraft to a ground station describing significant in flight conditions
AML	Aircraft Maintenance Log or equivalent, e.g. Aircraft Technical Log
ASHTAM	A special series NOTAM notifying a change in activity of a volcano, a volcanic eruption and/or volcanic ash cloud that is of significance to aircraft operations
ASR	Air Safety Report - used by an operator to document its safety incidents
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
CDM	Collaborative Decision Making
ETOPS	Extended Range Twin-engined Operations
FIR	Flight Information Region
IAVW	International Airways Volcano Watch - international arrangements for monitoring and providing warnings to aircraft of volcanic ash in the atmosphere
IVATF	ICAO Volcanic Ash Task Force
LIDAR	Light Detection and Ranging: an optical remote sensing technology counting among its capabilities that of detecting and measuring volcanic ash particle size and density
MEL	Minimum Equipment List
MET	Meteorological Service
MWO	Meteorological Watch Office
NAA	National Aviation Authority
NOTAM	Notice to Airmen - Notices concerning the establishment, condition or change to any facility, service or procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations
PMA	Parts Manufacturer Approval
SIGMET	Significant Meteorological Information message - information concerning en-route weather phenomena which may affect the safety of aircraft operations
SMS	Safety Management System
SRA	Safety Risk Assessment

STC	Supplemental Type Certificate
TCH	Type Certificate Holder
VAA	Volcanic Ash Advisory message
VAAC	Volcanic Ash Advisory Centre
VAG	Volcanic Ash Advisory message in graphical form
VAR	Volcanic Activity Report from aircraft (the real-time part of the VAR is issued in the same manner as an AIREP Special)
VO	Volcano Observatory
VOLCEX	Regular ICAO volcanic ash exercises to validate and improve regional volcanic ash contingency plans and procedures.

## H.2 Definitions

***Accountable Executive: Accountable Manager in the European system  
[definition needed.]***

**Affected Area:** A volume of airspace, an aerodrome or another area on the ground, identified by VAA/VAG and/or SIGMET as being affected by known or forecast volcanic cloud contamination.

***Danger Area:*** In the context of volcanic cloud contamination, a volume of airspace identified by NOTAM as being affected by high levels of known or forecast volcanic cloud contamination.

***(Aircraft) Operator:*** In the context of this document, references to the (aircraft) operator refer to those operators subject to ICAO Annex 6 Parts I, II and III being operators of large and turbojet aeroplanes including those involved in international general aviation. **[needs to be checked]**

**Service Provider:** In the context of this document, includes approved training organizations, aircraft operators and approved maintenance organizations, organizations responsible for type design and/or manufacture of aircraft, air traffic service providers, aerodromes, MWOs and VAACs.

***State of the Operator:*** The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

**State of Registry:** The State on whose register the aircraft is entered.

***Visible Ash:* [Needs formal definition from IVATF SCI Subgroup].**

**Volcanic Cloud:** The sum of the material ejected from a volcano into the atmosphere and transported by winds aloft. It comprises volcanic ash, gases and chemicals<sup>8</sup> (refer section 2.1 of ICAO Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds - Doc 9691).

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<sup>8</sup> Although the specific material being warned for used to be the ash contained in the volcanic cloud, it is understood that other elements of the cloud may also be undesirable to operate through

**Volcanic Ash:** is comprised of minerals unique to the volcanic eruption. Minerals common to most volcanic ash are silica together with smaller amounts of the oxides of aluminium, iron, calcium and sodium. The glassy silicate material is very hard and extremely abrasive. Its melting point is below jet engine burner temperature which introduces additional hazards. (refer section 2.1 of ICAO Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds - Doc 9691).

**Volcanic Ash Contamination Level:** An ash concentration level used to delineate airspace in which ash density is considered to have significance in safety terms.

**NOTE:** IVATF AIR 01/02, SCI and IAVW teams are in discussion to link this ash contamination level to levels of visible ash used historically to keep aircraft safe from ash hazards; for the 2010 Icelandic event, this was understood to be  $2 \times 10^{-3} \text{g/m}^3$ , a level adopted in the EUR/NAT region in Doc 019 Issue 6, Part II "Volcanic Ash Contingency Plan"<sup>9</sup>

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<sup>9</sup> The EUR/NAT volcanic ash contamination levels were defined as:

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

**Area of Medium Contamination:** Airspace of defined dimensions where volcanic ash may be encountered at forecast 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:** Airspace of defined dimensions where volcanic ash may be encountered at forecast concentrations equal to or greater than  $4 \times 10^{-3} \text{g/m}^3$ .

NOTES:

- All calculated ash concentration assessments are subject to a level of uncertainty.
- Downwind volcanic ash concentrations are dependent on the amount of ash coming, or which came, from the volcano, which is sometimes not known well.
- "Defined dimensions" refers to horizontal and vertical limits.
- Alternate means need to be established for areas of contaminated airspace where no ash concentration guidance is available.

## 3. IAVTF/2 – WP/ ATTACHMENT 2

/2011

**INTERNATIONAL VOLCANIC ASH TASK FORCE (IVATF)**

**Recommendations from the IVATF AIR 04 Team regarding pilot response to a volcanic cloud encounter.**

**SUMMARY**

The ICAO Volcanic Ash Task Force (IVATF) AIR 04 team has identified a need for operators to be clear about the actions to be taken by crews in the event that they encounter an ash cloud. The related material is of interest to the AIR 04 team but is within the direct remit of the AIR 05 team. As a result, the material developed by the AIR 04 team to date has been incorporated into this Attachment for it to be remitted to the IVATF AIR 05 team for their attention noting that there is also an overlap with the information set out in ICAO Doc 9766 (IAVW Manual) 4.7 "Action To Be Taken By Pilots In The Event Of Entry Into A S02 Cloud".

*(Presented by the IVATF AIR 04 Team)*

**19 APRIL 2011**

## **PILOT RESPONSE WHEN ENCOUNTERING A VOLCANIC CLOUD**

### **1 Recognising a volcanic ash encounter**

Note that airborne weather radar does not detect volcanic ash, and low concentrations may not be detected by the crew. The following are a list of symptoms which may be expected if volcanic ash is encountered:

- a) Odour: When encountering a volcanic ash cloud, flight crews usually notice a smoky or acrid odour that can smell like electrical smoke, burned dust, or sulphur;
- b) Static discharges: An electrostatic phenomenon similar to St. Elmo's fire or glow can occur. In these instances, blue-coloured sparks can appear to flow up the outside of the windshield or a white glow can appear at the leading edges of the wings or at the front of the engine inlets;
- c) Changing engine conditions: Surging and flameouts can occur; engine temperatures can change unexpectedly and a white glow can appear at the engine inlet;
- d) Engine restarts: Engines may accelerate to idle very slowly, especially at high altitudes (could result in inability to maintain altitude or Mach number);
- e) Haze: Most flight crews, as well as cabin crew or passengers, see a haze develop within the aircraft; dust can settle on surfaces;
- f) Airspeed: If volcanic ash fouls the pitot tubes, the indicated airspeed can decrease or fluctuate erratically, with associated effects on aircraft systems;
- g) Pressurization: Cabin pressure can change, including possible loss of cabin pressurization;
- h) Landing lights: Can cast sharp distinct shadows;
- i) Cockpit windows: Possible loss of visibility due to windows becoming cracked or discoloured due to the sandblast effect of the volcanic ash.

### **2 Escape from a volcanic cloud encounter**

Should volcanic ash be encountered, operators should follow the overriding recommendations of their TCHs. The following generalised response will normally apply:

- a) Make a 180° turn. Generally this will provide the shortest route out of the cloud, due to the possibility of it extending over a large area;
- b) Decrease thrust if conditions permit. High thrust and hence turbine temperatures increases the risk of volcanic particles melting and causing build-ups in the turbine area;
- c) Don crew oxygen masks (100%);
- d) Report to ATC. Any observation of volcanic activity or a volcanic ash encounter should be reported immediately to ATC using the VAR/AIREP procedures and subsequently by filing the more detailed part of the VAR;
- e) Increase bleed demand, e.g. select wing and engine anti-ice ON. This increases the surge margins and reduces the likelihood of a flameout;
- f) Start the APU. This provides an additional generator in case of a flameout;

- g) Monitor engine parameters and airspeed indications. The latter may be rendered unreliable by ash. Be prepared to use the unreliable airspeed indication drills;
- h) File an ASR and make an AML entry.

**Note:** The effects of volcanic ash on the engine may alter the engine in-flight restart envelope. Engine stall and surge margin can be reduced. Crews should be aware that loss of all engine power in such circumstance can result in significant altitude loss with restart altitude potentially far below the upper corner of the windmill relight envelope.