European Aviation Safety Agency — Rulemaking Directorate

Explanatory Note to ED Decision 2014/027/R and Comment-Response Document 2012-21

Volcanic ash ingestion in turbine engines

EXPLANATORY NOTE TO ED DECISION 2014/027/R
CRD TO A-NPA 2012-21— RMT.0364 (MDM.089) — 30.07.2014

EXECUTIVE SUMMARY

This combined Explanatory Note and Comment-Response Document (CRD) contains the comments received on A-NPA 2012-21 (published on 28 November 2012) together with a summary of the Agency's conclusions and proposed future activities.

The feedback provided during the consultation showed that stakeholders considered that there was no rationale to depart from the current ICAO operator-centric approach and that the concept of avoiding operations in visible ash clouds remained a strongly supported principle.

Based on stakeholders' views and taking into account available knowledge, reports and evidence, the Agency has concluded that there is no safety case that would justify an immediate and general rulemaking action to introduce a new volcanic ash airworthiness requirement for turbine engines.

The Agency will continue to monitor and assess volcanic ash related risks and to encourage further research activities that can contribute to a better understanding of volcanic hazards.

Applicability	
Affected regulations and decisions:	CS-E
Affected stakeholders:	Turbine engine and aircraft manufacturers
Driver/origin:	Safety, proportionality and cost-effectiveness
Reference:	N/A

Process map	
Concept Paper:	No
Rulemaking group:	No
RIA type:	None
Technical consultation during NPA drafting:	No
Publication date of the A-NPA:	28.11.2012
Duration of A-NPA consultation:	3 Months
Review group:	No
Focussed consultation:	No
Publication date of the Decision:	In parallel with this CRD

Table of contents

1. Procedural information

1.1 The rule development procedure

The European Aviation Safety Agency (hereinafter referred to as the 'Agency') developed this combined Explanatory note and Comment-Response Document (CRD) in line with Regulation (EC) No 216/2008[1] (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure[2].

This rulemaking activity is included in the Agency's Rulemaking Programme under RMT.0364 (MDM.089).

All interested parties were consulted through A-NPA 2012-21[3], which was published on 28 November 2012.

The text of this document has been developed by the Agency after due consideration of stakeholders' comments.

The process map on the title page contains the major milestones of this rulemaking activity.

1.2 The structure of this Explanatory Note/CRD and related documents

This Explanatory note/CRD provides a record and Agency analysis of stakeholder comments submitted in response to A-NPA 2012-21. In particular, it highlights the level of safety being achieved, safety hazards and operational issues that would benefit from additional knowledge, and stakeholder responses to the alternative strategies proposed by the Agency for future action. The document ends with the Agency's conclusions and proposed way forward.

A list of all stakeholder comments received is included for information only. Comments are not responded to individually but reflected in the general summary.

---

1 Regulation (EC) No 216/2008 of the European Parliament and 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), as last amended by Regulation (EU) No 6/2013 of 8 January 2013 (OJ L 4, 9.1.2013, p. 34).

2 The Agency is bound to follow a structured rulemaking 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'. See 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 Decision No 01-2012 of 13 March 2012.

3 http://easa.europa.eu/rulemaking/docs/npa/2012/A-NPA%202012-21.pdf.

2. Summary of comments

In total 113 comments were received from 16 stakeholders.

Five authorities commented on the A-NPA. The German LBA just informed that it had no comments on A-NPA 2012-21. Detailed comments were received from the CAA-N (Norway), the DGAC (France), the CAA-UK (United Kingdom) and the FAA (United States).

Four airframe manufacturers commented directly: Boeing, Airbus, Embraer and Eurocopter.

Two engine manufacturers commented directly: Snecma and Rolls-Royce.

In addition to direct input from some manufacturers, coordination of comments from this sector was provided by the International Coordinating Council of Aerospace Industry Associations (ICCAIA).

General Aviation provided comments through the SVFB/SAMA as a part of European Council of General Aviation Support (ECOGAS).

The operators' views were expressed through comments received from British Airways and from the International Air Carrier Association (IACA) which represents 30 airlines worldwide.

The Vereinigung Cockpit e.V. provided comments from the viewpoint of Germany's commercial pilots.

3. Comment analysis

3.1 General approach

Most stakeholders consider that maintaining an international approach is desirable. The achievements of the ICAO IVATF, following the 2010 Eyjafjallajökull volcanic eruption, were particularly noteworthy and have advanced the global understanding of how to manage airspace and operate safely and efficiently during future events. Continued support for the work coordinated by ICAO's International Airways Volcanic Watch Operations Group (IAVWOPSG) is expected to further enhance the safety and efficiency of aviation in future volcanic events.

However, some commentators added that reliance on ICAO should not be a barrier to continued improvements, and that Europe taking the lead in future developments should not be ruled out if this allowed for more rapid progress to be made.

Opinions expressed were unanimous in that there is no rationale to depart from the current ICAO operator-centric approach, whereby it is the responsibility of the operator, based on a safety risk assessment and supported by existing data streams, to decide whether to fly or not. The concept of avoiding operations in visible ash clouds remains a strongly supported principle.

3.2 Level of safety

Immediate safety of flight is assured through the avoidance of operations in high density volcanic clouds (i.e. visible or discernible ash). This requires operators to maintain up-to-date information to allow for tactical flight planning decisions and possible en-route course changes. The safety record has been good, with no incidences of aircraft encounters with high-density volcanic ash since the 80s/early 90s when the volcanic ash advisory centres (VAACs) were put in place[4]. Contributing to this success are:

- increased monitoring (satellite, airborne and ground based observations);
- enhanced forecasting techniques;
- SIGMET and NOTAMS;
- flight crew reports; and,
- advice from engine/airframe TC holders, who take a safe and conservative approach to maintaining exposure to low levels.

Changes to operational procedures to allow increased exposure to volcanic constituents was considered by many as a worthwhile future objective. However, it was recognised that this must remain a long-term goal due to the lack of detailed knowledge required to define aircraft limits (i.e. including the airframe, engines and occupants), together with the need for accurate, high-fidelity, real-time environmental data. Any move in this direction was largely seen as being driven by economics rather than safety.

With the current operating procedures in place, future safety enhancements are primarily associated with the following:

[4] On 13/02/2014 a Jetstar A320 entered the volcanic ash cloud from Mt Kelud, Java, Indonesia. The circumstances surrounding this encounter are currently under investigation.

i) The need to ensure that the peak level of exposure to volcanic constituents remains low. The principle of avoiding visible or discernible ash is seen by many as a simple and practical criteria. However, it can only be relied on if it remains valid at all times and in all weather conditions, even at night and in IMC. The consequences of operating into a unknown environment are that the assumptions forming the basis for the operator's safety risk assessment (SRA) may be invalidated.

ii) The need for increased knowledge of the cumulative effects of volcanic constituents on aircraft, engines and occupants due to prolonged exposure to dispersed volcanic clouds.

3.3 What should be done?

In A-NPA 2012-21, the Agency proposed 6 possible options to strengthen the existing rules and/or procedures related to flight in or near airspace contaminated with volcanic ash. Stakeholder comments on each of these options can be summarised as follows:

i) Option 0: Do Nothing

Most stakeholders agreed that the ICAO approach, whereby the operator undertakes a SRA, should be continued and there was no need or justification to impose new standards. However, greater confidence in the SRA process could be achieved if:

- engine/airframe operational limits were better understood;
- enhanced evaluation of existing types to operate under a SRA was undertaken;
- engine/airframes were evaluated for volcanic ash susceptibilities during certification; and,
- a common standard of SRA assessment was introduced.

ii) Option 1: Sand Testing

While sand testing has been used in the past to gain some understanding of the degradation in engine components (e.g. compressor blade erosion), commentators were of the opinion that sand testing would yield only limited data of any additional value. This was primarily due to the different properties of volcanic ash compared to sand.

iii) Option 2 : Research Programme

Commentators were unanimous in their views that further research was necessary.

It was noted that the cost of research should not be fully borne by the aviation industry, but be apportioned to reflect the wider benefits to society.

Identified research topics, could be established as follows:

a. *Ash science/threat identification/definition*

- Need to identify the critical constituents and features of ash.

  (Note: Initial guidelines on volcanic ash composition have been specified in IVATF/2 meeting Appendix 2B).

b. *Turbine engine ingestion testing*

- Insufficient knowledge of turbine engine behaviour in different ash environments;

- Extensive testing would be necessary to establish ash concentration limits and to quantify impacts;
- Possible engine modular testing should be considered to reduce timescales and cost;
- Need to assess the effects of ash ingestion on engines with deteriorated performance.

c. *Predictive ash dispersion forecasting models*

Better forecasting will enhance operational safety and efficiency. It could also reduce the reliance on monitoring and remote observations, providing a true all weather capability, including at night and in IMC.

d. *Airborne volcanic ash detectors*

On-board ash detectors could have multiple functions:

i. To facilitate in ash avoidance;

- Would need to be able to establish an in-flight quantitative reading that is relevant to any certified limit, and provide the flight crew with sufficient warning to avoid the area.
- What accuracy is required?
- Reliability of sensors and crew alerts to avoid unnecessary disruption.
- Need for verification and testing.

ii. To correlate predictive models;

- Could be used on non-revenue flights to supplement/verify forecasts that can be overly conservative.

iii. To monitor exposure to ash.

- To assist operators in monitoring each individual aircraft's level of exposure. This information could then be used to enhance safe operations under the SRA.

e. *Cost/Safety benefit analysis*

Several commentators proposed performing a Cost/Safety benefit prior to moving forward with any significant changes to the adopted ICAO position. Such an analysis would assess likely future disruption when operating to the latest ICAO guidance, including the impacts on commerce, the environment, and the cost of imposed design trade-offs. The outcome from this analysis could be used to identify the need for future certification requirements and provide the justification.

f. *Occupant health limit for volcanic cloud constituents.*

One commentator expressed the view that crew/passenger health could be the critical factor in establishing an ash tolerance level.

g. *Real-time and enhanced engine health monitoring*

i. Some form of trend shift parameter could be foreseen, with inputs such as engine oil temperature/pressure, EGT significant increase, vibration, etc.

ii. One objective would be to monitor the continued airworthiness of the engine and to trigger additional maintenance actions.

iii. For real-time monitoring, a pilot interface would be necessary to allow corrective action to be taken once a flight crew alert had been triggered.

iv) Option 3: New CS

One commentator stated that any introduction of a new CS should not be mandatory.

It was recognised that setting volcanic ash ingestion certification limits would only be effective if real-time environmental data is available to allow an in-flight assessment in a timely manner. Two data streams are, therefore, necessary;

a. a knowledge of volcanic ash capability; and

b. accurate, real-time local airspace environmental data.

While the measurement and forecasting of ash clouds is improving, commentators did not believe that the state-of-the-art in remote sensing and forecasting provided the required fidelity of ash concentration and precise location information that would be needed. The level of uncertainty with model outputs is too great at the moment to utilize as a tactical in-flight tool.

With regard to defining engine ingestion limits, commentators had the following opinions:

a. The move to certification rules was seen as premature.

b. No safety case was established.

c. Most stakeholders believe that it was not currently possible to design a test for a globally applicable requirement.

d. Most stakeholders consider that a new CS for volcanic ash should not take priority over other factors such as enhancing engine efficiency and the environment.

e. If not robust, any limitation may give operators a false sense of aircraft/engine capability.

f. Confidence in the SRA could be enhanced if engine/airframe manufacturers were to make a declaration of capability to volcanic cloud hazards for each of their products. This should take into account both ash concentration and duration of exposure. This does not necessarily mean a change in design to make engines more ash tolerant.

v) Option 4: Generic module testing

Commentators were generally in agreement that engine module testing should be considered. On the positive side, it was felt that module testing could speed up the availability of test results and could reduce the costs associated with testing. On the negative side, some doubt was raised as to how applicable these test results would be to individual aircraft and engines types.

vi) Option 5: Business Case

While not dismissing the concept, most commentators believed this would be a long-term objective.

One commentator stated that, under ICAO Doc 9974, the operators today are essentially setting their own exposure standards based on information from their experience as well as from the manufacturers.

However, it was recognised that 'exposure' cannot easily be defined by a single factor and that establishing a range of limits and robust instructions for continued airworthiness to support the operators, will be a problem for manufacturers.

4. Conclusions

Based on a synthesis of opinions expressed, the following general conclusions can be drawn:

i) Most commentators agreed that turbine engine issues could not be addressed in isolation, and that a holistic view, that also took into account the impacts on airframe and passengers and crew, was necessary.

ii) There is no rationale to depart from the current ICAO operator-centric approach.

iii) The concept of avoiding operations in visible ash clouds remains a strongly supported principle and has contributed to flight safety. It should therefore continue.

iv) Areas of continuing concern to safety and flight operations are:

   a. In ensuring that peak level of exposure to volcanic constituents remains low at all times and in all weather conditions, even at night and in IMC.

   b. The need for increased knowledge of the cumulative effects of volcanic constituents on aircraft, engines and occupants due to prolonged exposure to dispersed volcanic clouds.

v) There is no safety case for introducing a new engine Certification Specification. Establishing meaningful ash concentrations limits is considered impractical due to the variability of ash characteristics, as well as a lack of understanding of effects on total aircraft systems and aircraft occupants. Furthermore, the current state-of-the-art in volcanic cloud monitoring or forecasting, while improving, has not yet reached the stage where it can be used for an in-flight assessment against an airworthiness limitation. Introduction of a new engine CS is, therefore, premature and will not provide any safety, operational or economic benefit to operators.

vi) The need for additional research was strongly supported.

vii) The suggestion by one commentator that engine/airframe manufacturers should make a declaration of capability to volcanic cloud hazards for each of their products, is considered premature. The intent of the proposal has already been addressed by the Agency through changes to the airworthiness CSs (e.g. CS 25.1593 Exposure to volcanic cloud hazards), where the susceptibility of the product to the effects of volcanic cloud hazards must be established. Going further will require a test specification to be established, which is dependent on further research.

viii) Research into airborne volcanic ash detectors was mentioned by many commentators. However, a question remained as to whether this was the best use of resources with respect to volcanic ash.

5. Preferred Options

Most commentators believed that the fundamental principles developed in the latest ICAO guidance was both appropriate and safe, and that there was no fundamental need to depart from ICAO (Option 0).

Where the robustness of the operator's SRA had come into question, commentators were unanimous in the need for future research to increase the knowledge base (Option 2).

In the long-term, some commentators were supportive of moving towards a business case model (Option 5). However, this would only be possible once a better understanding of volcanic constituents and their impacts on aircraft, engines and occupants had been established.

6. Way Forward

With no safety case established to move ahead with airworthiness requirements for turbine engines, rulemaking task RMT.0364 will be closed once the additional data requirements from NPA 2011-17 has been incorporated on all affected CSs.

The management of volcanic hazards will primarily rest with the operator-centric procedures developed by the ICAO volcanic ash task force and adopted into European operational regulations[5]. To further enhance the robustness of the SRA performed by operators as part of these procedures, the Agency will encourage research programmes to be undertaken and will monitor their output. In particular, these programmes should include:

a. Turbine engine testing:

   i. Support for the ongoing US government-led VIPR testing. The aim is to gain basic knowledge in order to develop policies, strategies and decision.

   ii. The European WEZARD weather hazards research consortium should work closely with researchers in North America to develop a comprehensive engine and module research testing programme to advance the collective international knowledge of volcanic ash effects on turbine engines.

   iii. One of the difficulties in ground testing is the inability to replicate airborne conditions (concentrations, particle size, uniformity or lack of, etc.). In addition to testing, there was a need to learn from real experiences. TC holders have already set up a programme to collect and analyse data from operators

For information, a non-exhaustive list of completed or ongoing research activities is provided in Appendix 1.

b. Real-time and enhanced engine health monitoring

   i. Some data is already routinely available that can provide information on serious performance degradation.

   ii. SAE technical committee (ARP6212) is currently active.

c. Real-time on board technology measurement of volcanic ash to enhance ash avoidance:

   i. for individual aircraft;

   ii. for a group of aircraft that have established communication; and,

   iii. between a group of aircraft and ground sources

[5] ED Decisions 2013/006/R, 2013/007/R, 2013/008/R and 2013/009/R dated 16/04/2013.

Appendix 1: List Of Volcanic Ash Related Research Activities

Title	Code		Year	Status	Links	Remarks
RADAR-based ASH monitoring and forecasting by integrating of remote sensing techniques and volcanic plume models	RASHCAST	University of Cambridge	2011	Completed	Here	
Ash Ingestion Detection Apparatus for aircraft	AIDA	Greendbank Terotech Ltd	2013	On-going	Here	
Volcanic ash: field, laboratory and numerical investigations of processes during its lifecycle	VERTIGO	Ludwig-Maximilians-Universität München	2014	On-going	Here	
Weather hazards for aeronautics	WEZARD	Airbus Operations SAS	2011	On-going	Here	
Conditions of success for R&T Open options through a Platform of communications and for Expressing Recommendation Actions to Team-up Europe and U.S.	COOPERATUS	Aerospace and Defence Industries Association of Europe	2010	Completed	Here	
Support to Aviation for Volcanic Ash Avoidance	SAVAA	Norwegian Institute for Air Research	2009	Completed	Here	
Documenting ash fallout from the Eyjafjallajökull eruption in Belgium	-	Vrije Universiteit Brussel	2010	On-going	Here	
Volcanic ash plume dispersion by satellite imagery	-	Laboratoire de Télédétection aérospatiale Musée Royal d'Afrique Centrale Bruxelles	1994	On-going	Here	
Volcanic ash impact on the Air Transportation System	VolcATS	DLR	2012	On-going	Here	Link to workshop
Airborne Volcanic Ash Detection System	AVOID	Airbus & EasyJet	2013	On-going	Here	
A European volcanological supersite in Iceland: a monitoring system and network	-	Norwegian Institute for Air Research	2012	On-going	Here	
Volcanic Ash Strategic-initiative Team	VAST	Norwegian Institute for Air Research	2012	On-going	Here	

VOLCANIC ASH: FROM ERUPTION TO FLIGHT CHAOS	-	Ludwig-Maximilians-Universität München	2011	On-going	Here	
National Volcanic Ash Operations Plan for Aviation	-	Office of the Federal Coordinator for Meteorology	2007	On-going	Here	Plan
Hybrid Single Particle Langrangian Integrated Trajectory Model	HYSPLIT	National Oceanic and Atmospheric Administration	2012	Completed	Here	
Satellite Data Improving Volcanic Ash Forecasts for Aviation Safety	-	NASA	2013	Completed	Here	
Long-term monitoring experiment in geologically active regions of Europe prone to natural hazards: the Supersite concept	FUTUREVOLC	University of Iceland	2012	On-going	Here	
Volcano Global Risk Identification and Analysis	VOGRIPA	Bristol university	2005	Completed	Here	
Strengthening Resilience in Volcanic Areas	STREVA	Natural Environment Research Council	2013	On-going	Here	
Engine Damage to a NASA DC-8-72 Airplane From a High-Altitude Encounter With a Diffuse Volcanic Ash Cloud	-	NASA	2003	Completed	Here	
Experimental and Numerical Study of Particle Ingestion in Aircraft Engine	-	ASME	2013	Completed	Here	
Airborne aerosol in-situ observations of volcanic ash layers of the Eyjafjallajökull volcano in April & May, 2010, over central Europe	-	DLR	2010	Completed	Here	workshop
Volcanic Ash and Aircraft Engines	-	NLR	2010	Completed	Here	
Report of Falcon Flight 19 April 2010	-	DLR	2010	Completed	Here	workshop
Characterization of Eyjafjallajökull volcanic ash particles and a protocol for rapid risk assessment	-	University of Iceland	2011	Completed	Here	
Ash Safety Research Report	ASH SAFETY	University Politehnica of Bucharest	2010	Completed	Here	

Appendix 2: List Of Individual Comments

(General comments) -

comment *18* comment by: Ole J Mølstre, CAA-N

Norwegian CAA responses to A-NPA 2012-21
We have concentrated on the questions in the A-NPA and commented them
Question 1
Is there any rationale to depart from the current ICAO approach: i.e. operation is the responsibility of the operator, based on a safety risk assessment and supported by existing data streams?
No
Question 2
Is there a clear, objective-based safety benefit that would be achieved by imposing a new certification standard?
We doubt it since todays regime is conservative we believe the greatest benefits would be economical for the operators and the community.
Question 3
Given the high traffic densities of European airspace and the frequent requirement for operation in IMC, and given also the enhanced capabilities in Europe to detect and track volcanic ash, should EASA propose a standard applicable only in European airspace?
EASA makes the rules for European airspace and since the industry is global this rulemaking should be aligned with the rest of the world through ICAO and possibly through bilateral agreements.
Question 4
Is harmonisation of EASA standards with those of other States of Design (e.g. USA and Canada) of such importance in respect of volcanic ash that it should take priority over a solution for Europe?
Experience has shown that Europe has potential for serious implications for their aircraft industry so it will be wise to prioritize Europe first.
Question 5
Could sand testing provide any benefit to enhance the information available to operators for use within their VA SRAs?
It will be of limited value since sand has other properties than volcanic ash. And in fact each eruption of volcanic ash will have different properties from the other.
Question 6
What activities could be considered in this context (Advances in detection/improved health monitoring/engine research testing) **and which would merit prioritisation?**
Advances in detection will more clearly state where ash is present, this will give the fastest operational results on the existing regime. Secondly will a combination of airborne detection along with improved health monitoring (engine and aircraft) help in gaining experience, but this will have to be supported by engine(and aircraft) testing and research.
Question 7
What characteristics would on-board equipment need to have in order to deliver significant operational benefit?
On-board equipment need to have the characteristics operators need to manage the airworthiness. In other words this has to be defined by the different TCH/STCH. E.g. things like exposure time, exposure level total exposure, etc
Question 8

The introduction of a Certification Specification may drive engine manufactures to design an ash tolerant engine that detrimentally impacts emissions, fuel burn, required maintenance actions and cost. What would be an acceptable compromise to stakeholders?
This will have effect on the environment and cost for the operators and the communities. Other stakeholders will have to draw the " acceptable line".
Question 9
Can a certification test be adequately defined to address a globally applicable requirement?
As each volcanic eruption will have different properties regarding the contents it will be difficult to develop one or even a number of tests that will be representative.
Question 10
Have engine TC holders already foreseen the need to undertake specific engine volcanic ash testing? If so, can you give details of the test specification to be used?
No knowledge.
Question 11
What benefits could generic module testing produce and would those benefits merit taking this work forward?
As each volcanic eruption will have different properties regarding the contents it will be difficult to develop one or even a number of tests that will be representative. In addition generic tests will have limited value to a specific engine and aircraft
Question 12
Would such information(option 5: Business case**) offer benefits sufficient to merit taking this work forward?**
This will require the TCH/STCHs to establish upper and lower limits and this establishment of limits will be the problem for this model. Additionally TCH/STCHs have to develop robust airworthiness instructions to support the operators.
Question 13
What option(s) do you consider to be most appropriate and why?
Add others if none of the above.
We consider that it would be wise to continue todays regime and encourage the development of better methods to detect ash and determine density levels. And also on-board equipment to better determine the exposure to ash and hence improve the SRAs. Although it seems very difficult we also want TCH/STCHs to test and analyze their products to support the operators operations and improve their SRAs.
Question 14
What is needed to move towards establishing engine ingestion limits?
Extensive testing and analizes. There will not be a single limit possible for all engines on the globe.
Question 15
In the absence of a Certification Specification for ash ingestion capability, how will volcanic ash tolerance be ensured for future engines?
If safe levels are impossible to determine we will have to adhere to todays regime and make improvements to this.
Question 16
Can you quantify expected costs and other impacts for the various options?
No

comment *19* comment by: *DGAC France*

With this A-NPA the Agency aims at identifying different options available, within its jurisdiction, in order to quantify and reduce the impact of volcanic ash ingestion in turbine engines.
First of all, it seems useful to emphasize that the French DGAC would like the concept of visible ash to be strongly associated with future regulation works since an acceptable level of safety has been evidenced for flights occurring outside a visible ash cloud. This concept should remain as simple as possible (that is visible to the crew's naked eye) to ensure its operational applicability. Since the concept of visible ash cannot be used in all conditions (night VFR or IMC), a better understanding of the impact of volcanic ash ingestion in turbine engines is needed. Thus the Agency's plan of action is considered valuable by the French DGAC.
Concerning the operational safety risk assessment (SRA), which is required before conducting flight operations in areas that are forecast to contain volcanic ash, it would be desirable that operators have access to clearer and more homogeneous means of decision. The supply of technical data by engine TC holders on one hand and an improvement in the forecast of volcanic ash locations and concentrations on the other hand should contribute to this goal.
A rigorous certification process, based on airworthiness limits applicable to turbine engines, seems premature. Indeed, the diversity of ash characteristics, engine designs, flight plans and volcanic ash contamination forecasts' precisions make it quite difficult to set precise concentration limits usable in a certification process. Moreover, imposing changes in conceptions only to allow flights to be conducted in certain contaminated areas would have negative impacts on cost, performance, emissions and reliability without any real operational or safety benefit.
It seems more convenient that the Agency promotes the pursuit of research programs among plane manufacturers and engine TC holders and the supply of information concerning turbine engines' robustness in areas contaminated by volcanic ash. The latter would notably help operators to prepare their safety risk assessment.

comment *41* comment by: *Boeing*

GENERAL COMMENT:
Boeing Commercial Airplanes appreciates the opportunity provided by EASA to review and comment on the advance-NPA.
We totally support the comments submitted to this A-NPA by the International Coordinating Council of Aerospace Industries Association (ICCAIA) [reference letter ICCAIA/AC/064, Subject: "ICCAIA Airworthiness Committee comments on EASA Advance Notice of proposed Amendment A-NPA 2012-21, Volcanic ash ingestion in turbine engines"].

comment *58* comment by: *Luftfahrt-Bundesamt*

The LBA has no comments on A-NPA-2012-21.

comment *76* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

Embraer supports the comments to A-NPA 2012-21 made by the Airworthiness Committee of the International Coordinating Council of Aerospace Industries Associations in their letter ICCAIA/AC/064. Embraer believes that the current state-of-the-art of volcano monitoring and airborne ash detection is insufficient to provide any safety, operational, or economic benefit to operators that might be affected by future volcanic eruptions that impact European airspace. Also

important is that fact that any engine design changes required to increase robustness to allow operation in ash-contaminated airspace during the relatively rare event of volcanic eruption will result in unacceptable everyday impacts in fuel consumption and carbon production.
Embraer believes that further research in engine susceptibility to ash contamination could aid operators in further optimizing their volcanic ash risk assessment processes, and that both industry and government should continue to contribute to these efforts. Other efforts in improving the timeliness and accuracy of volcanic ash detection, whether on-ground, in flight, or satellite-based, will similarly serve to reduce future impacts of volcanic eruptions that affect European airspace.
Embraer appreciates the opportunity to comment to this A-NPA.

comment *78* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

ICCAIA represents the Aerospace Industry Associations of Europe, the United States of America, Brazil, Canada, Japan and Russia. These industries develop, produce and maintain an overwhelmingly large percentage of the civil aircraft fleets operating around the world. Our Member associations are grateful for the opportunity to comment on Advance Notice of Proposed Amendment (A-NPA) No. 2012-21, "Volcanic ash ingestion in turbine engines". As requested, we have introduced our comments into the EASA CRT. In parallel to our CRT inputs,the ICCAIA Airworthiness Committee issued letter Ref. ICCAIA/AC/064 which will reach you in the coming days by postal distribution. In an Attachment to that letter, we provide our comments as introduced into the CRT. In advance, copies of the letter and the attachment have been transferred into the CRT. For any question, or information needed to process, or clarify, our inputs, EASA is kindly asked to contact the ICCAIA Airworthiness Committee under the e-mail address registered for the CRT. Thank you!	ICCAIA Responses on EASA A-NPA2012-21 28-02-13.pdf ICCAIA AC Letter 064 Comments on EASA A-NPA 2012-21_280213.pdf

comment *79* comment by: *AIRBUS*

Airbus contributed to, and supports as a member, the comments and responses provided by ICCAIA in the letter ref. ICCAIA/AC/064 and in the attachement to this letter.

comment *80* comment by: *Snecma*

Please see attached letter from Snecma Extract from letter : General comment Snecma was involved in the ICCAIA review process of the A-NPA 2012-21 and fully supports the comments and	Snecma letter YES 492-13-MH_Snecma comments on NPA 2012-21.pdf

responses published by the ICCAIA under reference ICCAIA/AC/064.	

comment 97 comment by: *Rolls-Royce plc (ZM)*

Rolls-Royce plc have been actively involved in generating the comments submitted in the ICCAIA response (reference ICCAIA/AC/064, Subject: "ICCAIA Airworthiness Committee comments on EASA Advance Notice of proposed Amendment A-NPA 2012-21) and we fully endorse these comments.
Regards
Zaki Mahroof
Airworthiness (E&T)
Rolls-Royce plc

comment 98 comment by: *James Crotty, FAA*

PDF attachment.	FAA Response-A-NPA 2012-21 Comment Response FINAL-28 FEB 2013.pdf

comment 99 comment by: *James Crotty, FAA*

COMMENT #1 of 13
Affected paragraph and page number:
Page: GENERAL COMMENTS TO A-NPA
Paragraph: n/a
General Comments:
International nature of volcanic eruptions and aviation necessitates a global approach and collaboration.
Continued global collaboration through ICAO's IAVWOPSG can produce enhancements to airspace management and operational efficiencies that benefit all regions.
Establishing meaningful ash concentrations limits is considered impractical due to variability of ash characteristics and accuracy of concentration forecasts, as well as a lack of understanding of effects on total aircraft systems and aircraft occupants.
Manufacturer's Airplane and Engine defined flight crew awareness and maintenance inspection procedures provide for continued airworthiness. These have proven to be effective and continue to evolve based on lessons learned and collective experience shared in ICAO document development.
Potential design changes to equipment to survive a defined volcanic ash threat level are likely to negatively affect equipment cost, performance, emissions and reliability without substantial operational or safety benefit.
Since the introduction of the volcanic ash advisory centers (VAACs) and enhanced communication channels within the aviation community, the number of significant in-flight volcanic ash encounters has diminished dramatically over the past few decades. Continued enhancement of communication channels will further improve safety and operational efficiency.
Avoiding operations in visible/discernable ash has demonstrated flight safety as demonstrated by historical event experience.
This A-NPA proposed regulatory action is considered unnecessary, premature and

would potentially negatively impact safety through giving the Operator's a false sense of security that the aircraft can fly in conditions that are not well characterized.
Volcanic eruption events have exemplified their uniqueness relative to the ash characteristics and how it moves in the atmosphere. Trying to identify a single test to capture the wide variation in eruptive events may not prove achievable nor of any real value to Operators.

ADVANCE NOTICE OF PROPOSED AMENDMENT (A-NPA) 2012-21 'Possible courses of action for EASA to address the issue of volcanic ash ingestion in turbine engines' — General comments -

comment *1* comment by: *SVFB/SAMA*

2012-21
SAMA a member of ECOGAS

There have been enough and expertly comments by manufacturers adressing specific points.

We have only three principal comments:

1) The fact that the decision in such a critical matter with high risk potential is finally delegated to the operator is a bold discrepancy when compared to regulate every tiny bit and piece when it comes to potentially small risks in the maintenance of GA & Business aviation. If the same amount of freedom offered here to airlines (which we do not discuss) would be applied in maintenance of GA and Business aviation we would have a much better regulation.

2) we find it extremely disturbing that in such a critical matter, there are three institutions, ICAO, FAA and EASA who compete with extremely different opinions. If in matters of such common importance a common ground between friendly neighbours cannot be found, communication is definitely less than optimal.

3) If the solution finally is only accepted because two of the three partners give in to the stringent rulemaking of the most demanding partner, then this is THE demonstration as to why the European Rulemaking is leading to ever more complex and more voluminous rules. These process of rulemaking is the reason which leads in many if not most rulemaking cases to a resulting most demanding rule of 27 participating parties.

We remain with the very best wishes for a healthy and successful 2013

SAMA
a member of ECOGAS

Franz Meier

comment *92* comment by: *British Airways*

The challenges presented by choosing to certify upper and lower limits for ash ingestion on turbine engines and the value of taking this approach are significant.

As mentioned in the A-NPA, volcanic ash emissions vary not only by individual volcano but vary by each different eruption at a single volcano. Operators would choose to avoid operations in areas where ash concentrations were such that they had an economic impact on the airframe that exceeded the economic value of operating a sector through that area. To make a decision to operate into a known area of ash concentration above the current 'visible/discernable' threshold requires the ability to assess that threshold in-flight to a high level of confidence.
There is little safety benefit or indeed operational benefit to having a known threshold for engine ash ingestion limits without the ability to make an in-flight assessment, in such a timely manner, that allows the aircraft to avoid concentrations above any certified threshold. The level of uncertainty with model outputs today is too great at the moment to utilise as a tactical inflight tool.

A. Explanatory Note — I. General; II. Consultation; III. Comment-Response Document (CRD) -

comment *100* comment by: *James Crotty, FAA*

COMMENT #2 of 13
Page: 4 of 18
Paragraph: Section A. Explanatory Note, I. General 1.
The proposed text states: "*This A-NPA has been developed by the Agency with support from manufacturing industry. Its primary aim is to solicit the views and experience of stakeholders on future options for addressing volcanic ash ingestion in turbine engines.*"
REQUESTED CHANGE: Research is needed to establish the risk to airplane, mechanical and electrical systems, powerplant and occupant health prior to any rulemaking activity.
Furthermore, we recommend that EASA evaluate volcanic ash and volcanic cloud constituents' exposure limits to ensure occupant health and safety. Safe occupant inhalation limits may potentially be at lower levels than those that can be tolerated by turbine engines, airplane structure, mechanical and electrical systems, and powerplant.
JUSTIFICATION: Research is required to determine the level of volcanic ash contaminant that permits safe engine operation. Currently there is no data to justify an acceptable level thus the ICAO rationale for visible and discernible as to keep aircraft out of ash contaminated airspace. In addition there is no data to define a safe threshold for occupant safety, which may potentially be at a much lower level than the powerplant, systems and structure threshold levels.

B. Possible courses of action — IV. Background -

comment *93* comment by: *British Airways*

Para 12 states that VAACs have developed models 'to forecast the location and concentrations of volcanic ash within the airspace'. The outcome of the work of the IVATF-SCI questioned the validity of the models to produce variations of ash concentrations of such a small magnitude of variation over such a large area. This was supported by a proposal to cease the work and production of ash concentration charts.

para 13. The response to the possible impact of aircraft avoidance was not based on any actual experience ANSPs had of managing operations in the affected areas in 2010. Had normal weather avoidance flow measure been put into place a operations would have continued. The flow rates were reduced to zero based on anticipated pilot response and not actual experience of operations in the affected areas.

comment *101* comment by: *James Crotty, FAA*

COMMENT #3 of 13
Page: 6 of 18
Paragraph: B. Possible courses of action IV. Background 15
The proposed text states: *"existing principle that flight in ash visible to the naked eye should be avoided. Furthermore, advice from TC holders has been to limit exposure to volcanic ash by setting criteria such as 'not exceeding 2mg/m^3' to restrict flight operations, and that an ash concentration of 2 mg/m^3 could be used as indicative of visible ash for flight planning and night flying purposes."*
REQUESTED CHANGE: EASA should corroborate the safety of the proposed ash concentration level by supporting research before requiring compliance testing. EASA should get international agreement before establishing limits on volcanic cloud constituents (i.e., gases).
JUSTIFICATION: We are aware of no definitive existing test results showing that flight through an atmosphere contaminated with volcanic ash at a concentration of 2 mg/m^3 is safe for airplane, mechanical and electrical systems, powerplant and occupant health. The use of 2mg/m ^{3} has been proposed as criteria to be used by forecasters to determine the area of discernible ash but it is not a substantiated value for engine susceptible to ash. The FAA believes that research is needed to demonstrate that this particulate concentration level is safe for airplane, mechanical and electrical systems, powerplant and occupant health for continuous flight.

B. Possible courses of action — V. Aims and scope of this A-NPA -

comment *102* comment by: *James Crotty, FAA*

COMMENT #4 of 13
Page: 6 of 18
Paragraph: V. Aims and scope of this A-NPA, 20
The proposed text states: *"Aircraft systems, structure and also crew/passengers will also be affected by exposure to volcanic hazards. While not underestimating the effort required to amend the applicable Certification Specifications to address these issues, it is not the intent to address these issues here. This will only be contemplated once a clear direction on the setting of turbine engine ash ingestion limits has been established."*
REQUESTED CHANGE: The FAA recommends that EASA assess safe occupant inhalation limits for volcanic ash concentration and volcanic cloud constituent. Limits to ensure occupant health may establish the upper boundary of acceptable exposure to volcanic ash and volcanic cloud for continuous flight
JUSTIFICATION: The FAA agrees that approval for continuous flight through an atmosphere contaminated with volcanic ash and volcanic cloud constituents will require an assessment of the impact on all aspects of airplane safety. However, an acceptable volcanic ash concentration limit for turbine engines may potentially be greater than an acceptable limit for the occupants. Current U.S. health limits

for inhalation of other particulate material fall far below the 2 mg/m^3 discussed within this NPA. Additionally elevated levels of SO2 can be lethal to humans and should be directly addressed, before rulemaking allows tacit approval to fly in these ash and SO2 clouds. We believe that the threshold level for safe inhalation of volcanic ash and SO2 will potentially be a more critical limit and suggest that a priority be put on establishing that limit prior to testing sensitivity of powerplant, airplane systems and structure.

comment *103* comment by: *James Crotty, FAA*

COMMENT #5 of 13
Page: 7 of 18
Paragraph: V. Aims and scope of this A-NPA, 21
The proposed text states: *"In addition to the threat from ash, there are other identified threats from volcanic cloud constituents (e.g. CO_2, SO_2, H_2S, H_2, CO, HCL, HF, He, H_2SO_3, and H_2SO_4). These additional threats are added here for completeness but are not considered further in this A-NPA. If an airworthiness approach is to be taken forward, these threats will need to be considered in defining the airworthiness limitations and certification standards."*
REQUESTED CHANGE: The FAA recommends that EASA assess the occupant safety limit first as these limits may establish the upper boundary of acceptable exposure to volcanic cloud constituents and/or associated material after ingestion.
JUSTIFICATION: The FAA agrees that approval for continuous flight through an atmosphere contaminated with volcanic ash and volcanic cloud constituents will require an assessment of the impact on all aspects of airplane safety. However, an acceptable volcanic ash and SO2 concentration limit for turbine engines may potentially be greater than an acceptable inhalation limit for the occupants. This should be studied before any rulemaking is initiated.

B. Possible courses of action — VII. Objective of airworthiness limits -

comment *83* comment by: *Vereinigung Cockpit e.V.*

The upper limits seems to high for our experience (minimum one order of magnitude)...

B. Possible courses of action — IX. The case against setting engine ash ingestion limits -

comment *2* comment by: *EUROCOPTER*

Eurocopter's answer to Question 1*:*
No we should keep adopting the ICAO approach as long as Volcanic Ash (VA) data (= the threat) are not defined and internationally harmonized. New certification standards could in our opinion only be envisaged for the future, provided they are based on harmonized VA data and that these standards are harmonized EASA/FAA/TCCA.

comment *20* comment by: *DGAC France*

Question 1:

No, the current ICAO approach based on the operator's responsibility is satisfactory. An improvement and a harmonisation of SRAs should be promoted (better supply of information by engines TC holders and forecasts information in particular).

comment *25* comment by: *UK CAA*

Page No: 10 of 18
Paragraph No: **Question 1**: Is there any rationale to depart from the current ICAO approach: i.e. operation is the responsibility of the operator, based on a safety risk assessment and supported by existing data streams?
Comment: We believe that the approach of providing responsibility to the operator based on a safety risk assessment (SRA) supported by existing data streams is correct, however, we believe that by having a greater understanding as to acceptable ash operability limits for engines and airframes it will provide greater levels of confidence in the safety standards. UK CAA believes that more can be done to evaluate permitting existing types to operate under safety risk assessments, and also to establish safe operational limits during the certification of new engine and airframe types.
Justification: Experience from the recent eruption has indicated that there is scope for improvement in understanding tolerance to ash and controlling aircraft operations in dispersed ash conditions. With a greater understanding in place it would become evident whether safe operations could be ensured during the course of prolonged, dispersed volcanic ash activity.

comment *42* comment by: *Boeing*

QUESTION 1:
Commercial jet aviation has been operating safely and efficiently for many years since the hazards associated with operations in volcanic ash have been identified and airspace and flight operational procedures have been established. This successful history has been based on avoiding operations in a visible ash cloud or ash discernible by satellite imagery, ground observers, flight crew, and pilot reports, augmented by forecasting model predictions and Significant Meteorological Information (SIGMETs) and Notices to Airmen (NOTAMs) as required. ICAO's Annex 3, *Meteorological Service for International Air Navigation,* and the World Meteorological Organization's Technical Regulation C.3.1 control the standards for dissemination of information about volcanic ash to the aviation community. ICAO has also published the *Handbook on the International Airways Volcanic Watch* (Document 9766), which defines the responsibility and operational procedures for distributing information on volcanic eruptions and associated ash clouds that could affect routes used by international flights.
After the 2010 Eyjafjallajökull event, ICAO formed an International Volcanic Ash Task Force (IVATF) to assimilate the world's best practices for addressing airspace control during a volcanic eruption, the latest scientific information on detection and forecasting of volcanic ash clouds, manufacturer's recommendations for aircraft and engine operations during volcanic eruption events, and airline operations. The IVATF developed:
- Comprehensive airline operational guidance material on *Flight Safety and Volcanic Ash - Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination* (Doc 9974);
- Comprehensive additional guidance material for ICAO's *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691), advancing the understanding of the airworthiness effects of flight into a volcanic ash cloud, and

the mitigating actions and maintenance considerations that need to be taken in the event of an encounter; and
- Comprehensive assessment of existing *Volcanic Ash Advisory Center* (VAAC) products (including enhancement thereof) and made good progress implementing best practices among the VAACs, identifying tools and associated procedures that may be suitable to foster a collaborative and consistent response to volcanic eruptions
The knowledge and data garnered from the Eyjafjallajökull event, along with the good work from the IVATF, have advanced the global understanding of how to manage airspace and operate safely and efficiently during a volcanic eruption event. The 2012 Grímsvötn event, while not a significant eruption, did demonstrate a significant improvement in airspace management and flight operations, based on continuing experience and improvements in contingency planning for volcanic eruptions. Therefore, Boeing does not feel that there is any rationale to depart from the current ICAO approach.

comment *59* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 9/10 of 18
Question 1:
Is there any rationale to depart from the current ICAO approach: i.e. operation is the responsibility of the operator, based on a safety risk assessment and supported by existing data streams?
ICCAIA Comment/Response on Question 1:
Commercial jet aviation has been operating safely and efficiently for many years since the hazards associated with operations in volcanic ash have been identified and airspace and flight operational procedures have been established. This successful history has been based on avoiding operations in a visible ash cloud or ash discernible by satellite imagery, ground observers, flight crew, and pilot reports, augmented by forecasting model predictions and Significant Meteorological Information (SIGMETs) and Notices to Airmen (NOTAMs) as required. ICAO's Annex 3, *Meteorological Service for International Air Navigation,* and the World Meteorological Organization's Technical Regulation C.3.1 control the standards for dissemination of information about volcanic ash to the aviation community. ICAO has also published the *Handbook on the International Airways Volcanic Watch* (Document 9766), which defines the responsibility and operational procedures for distributing information on volcanic eruptions and associated ash clouds that could affect routes used by international flights.
After the 2010 Eyjafjallajökull event, ICAO formed an International Volcanic Ash Task Force (IVATF) to assimilate the world's best practices for addressing airspace control during a volcanic eruption, the latest scientific information on detection and forecasting of volcanic ash clouds, manufacturer's recommendations for aircraft and engine operations during volcanic eruption events, and airline operations. The IVATF developed:
- Comprehensive airline operational guidance material on *Flight Safety and Volcanic Ash - Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination* (Doc 9974);
· - Comprehensive additional guidance material for ICAO's *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691), advancing the understanding of the airworthiness effects of flight into a volcanic ash cloud, and the mitigating actions and maintenance considerations that need to be taken in the event of an encounter; and
· - Comprehensive assessment of existing *Volcanic Ash Advisory Center* (VAAC) products (including enhancement thereof) and made good progress implementing

best practices among the VAACs, identifying tools and associated procedures that may be suitable to foster a collaborative and consistent response to volcanic eruptions
The knowledge and data garnered from the Eyjafjallajökull event, along with the good work from the IVATF, have advanced the global understanding of how to manage airspace and operate safely and efficiently during a volcanic eruption event. The 2012 Grímsvötn event, while not a significant eruption, did demonstrate a significant improvement in airspace management and flight operations, based on continuing experience and improvements in contingency planning for volcanic eruptions. Therefore, ICCAIA do not feel that there is any rationale to depart from the current ICAO approach.

comment *84* comment by: *Vereinigung Cockpit e.V.*

From our point of view the avoidance principles is critical due to the fact that is very difficult to define VA clouds...

comment *85* comment by: *Vereinigung Cockpit e.V.*

In the following answers, reference is made to ´´ash´´. Volcanos emit ash and an aerosol that is subsumed under the name of ´´SO2´´. This aerosol contains extremely fine ash as well as gas, acid and fine solids, all of which are chemically active. Some of these chemicals are known to attack the high-temperature resistant coatings of turbines, and have been implicated in engine failures.
In the following answers, the term ´´VA and SO2´´ is used as shorthand to describe the above.
Question 1
The idea of setting engine limits is supported.
Volcanos have been around since forever, volcanic ash represents a normal, natural phenomenon. We have environmental limits for engines, have estabilished test procedures for bird ingestion, and have requirements for sand / dust ingestion testing, like RTCA Document DO-160, Section 12, Category D or MIL-STD-810E, which are vaild for electric and electronic components.
Therefore, as VA and SO2 represents a naturally occuring phenomenon, engines and other aircraft parts have to be tested and reasonable limits have to be established.

comment *94* comment by: *British Airways*

EASA should refrain from moving alone to propose a standard for Europe in isolation. Other areas of the globe have significant experience of operating in airspace impacted by volcanic ash. Harmonisation and the development of a global standard is more effective as shown with the work of the IVATF.

comment *112* comment by: *James Crotty, FAA*

IX. The case against setting engine ash ingestion limits (p. 9 of 18)
Question 1:
Is there any rationale to depart from the current ICAO approach: i.e. operation is the responsibility of the operator, based on a safety risk assessment and supported by existing data streams?
Currently, no valid rationale has been identified to depart from the ICAO approach to flight safety after a volcanic eruption. ICAO has been developing and improving

guidance and standards since the implementation of the International Airways Volcano Watch Operations Group that provides oversight to the nine Volcanic Ash Advisory Centers. As the science advances it is expected that model output and remote sensing improvements will provide a more robust means to monitor, track and advise operators and ANSP on the location of the ash cloud. Proof that these evolving ICAO standards and guidance is effective can be seen in the last twenty years there have only been two aircraft power loss events (one event in July 2001 and another in July 2006, per the USGS Data Series 545, *http://pubs.usgs.gov/ds/545/DS545.pdf#*) and no accidents have occurred. Recent ICAO guidance to Operators in ICAO Document 9974 has further enhanced the available guidance, recognizing the Operator's responsibility to assure a safe flight has been embraced worldwide and has been shown to improve safety.

B. Possible courses of action — X. The case for setting engine ash ingestion limits -

comment *3* comment by: *EUROCOPTER*

Eurocopter's answer to Question 2:
Such a safety benefit could only be reached if adequate and internationally agreed VA data, and adequate VA concentration measuring devices exist.
Nevertheless, as for certification to icing, the certification to ash should not be mandatory:
A certain similarity with the "Icing Conditions" could be done, since the presence of ash can be detected by ground detection network with regular refreshment.
If the certification to VA is done, flights in ash clouds can be performed, with the necessary kit protections (if needed), and maybe with a limitation on the adequate parameters as the concentration (in that case a regular information about the parameter needs to be available onboard).
The fact to be obliged to survey a parameter shows a similarity with the "Limited Icing Conditions".
If the certification to VA is not done, adequate limitations are needed, that could include the prohibition to fly.

comment *4* comment by: *EUROCOPTER*

Eurocopter's answer to Question 3:
No, the VA threat having a worldwide scope of action, any EASA certification standard, if decided to be launched, should be harmonized at least with the FAA and TCCA and applicable also in the airspaces regulated by these authorities. Moreover, imposing a standard which is applicable only in the European airspace would have a negative economic impact on the European air transport.

comment *5* comment by: *EUROCOPTER*

Eurocopter's answer to Question 4:
Eurocopter considers that Researches on the VA threat definition and on the engine behaviour to VA contamination have to be engaged first (option 2). This step could be continued by the activity of a CS determination (option 5) provided VA threat is defined and internationally harmonized. If such a condition is met and if the activity of defining an EASA standard is started, yes harmonization of this standard with the FAA and TCCA should take priority over a solution for Europe.

comment *21* comment by: *DGAC France*

Question 2:
No. A new certification standard would be primarily motivated by an operational objective, with a questionable safety benefit.

Question 3:
No. A standard only applicable in European airspace would not make sense. Aircrafts and operators are generally not confined to European airspace. Moreover, imposing specific constraints in Europe could lead to a negative economic impact on European air transport.

Question 4:
The French DGAC considers that it's the research on turbine engines' resilience in areas contaminated by volcanic ash that should be promoted in priority, before planning on any certification process. This being considered, Europe could launch specific research programs, or actions in collaboration with non European countries. For instance, a joint reflection between the EASA and the FAA on the risks induced by ash ingestion in turbines engines is desirable.

comment *26* comment by: *UK CAA*

Page No: 10 of 18
Paragraph No: Question 2: Is there a clear, objective-based safety benefit that would be achieved by imposing a new certification standard?
Comment: The safety objective of newly certificated products would be to establish more clearly defined safety standards for operations in dispersed volcanic ash. Rather than for the CS to establish a target minimum ash tolerance level, we believe that a more objective approach would be for the engine manufacturer to declare an operability tolerance to ash, which takes into account both ash concentration and exposure time/duration.
Justification: For new products a new CS would establish and verify acceptable ash concentration levels that airframes and engines could operate within. Although there could be benefits in clarifying, "avoiding operations in visible ash", there could be safety benefits in establishing and maintaining better standards for operation, particularly with respect to operations in night and IMC conditions.

comment *27* comment by: *UK CAA*

Page No: 10 of 18
Paragraph No: Question 3: Given the high traffic densities of European airspace and the frequent requirement for operation in IMC, and given also the enhanced capabilities in Europe to detect and track volcanic ash, should EASA propose a standard applicable only in European airspace?
Comment: It is always preferable to have a harmonised engine/airframe certification specification relevant to all new certificated products. Volcanic activity does occur in other high air traffic regions in the world, which would benefit from the lessons learnt from the European/Icelandic volcanic experiences. If the CS was to stipulate a declaration of operability tolerance to ash (as opposed to requiring new products to meet a declared minimum standard) then it would be possible to apply the CS standard as only applicable to air traffic movements in a European environment, should this be necessary.
Justification: Europe could lead in enhancing safe operations in a dispersed ash environment, and other world regions would have the option of following should they wish, subject to lessons learned and infrastructure capability.

comment *28* comment by: *UK CAA*

Page No: 10 of 18
Paragraph No: **Question 4**: Is harmonisation of EASA standards with those of other States of Design (e.g. USA and Canada) of such importance in respect of volcanic ash that it should take priority over a solution for Europe?
Comment: Harmonisation of Certification Specifications is always the preferred ideal, and every effort should be made to achieve a harmonised standard but this should not take priority over achieving a satisfactory design objective. In the worst case, the end result could lead to a Significant Regulatory Difference (SRD) being developed. If all the manufacturers, however, could be committed to supporting research programmes into the effects of ash, then this would be a less likely outcome. In a situation where the CS requires a declaration of capability (in terms of operability in dispersed low ash concentration environments) rather than meeting a clear design specification, harmonisation and SRDs then become less arduous.
Justification: The priority in Europe is, where possible, to ensure the safe operation of aircraft in a dispersed ash environment should a future volcano erupt and threaten to disrupt air traffic in that region. To achieve this activity within a reasonable timeframe it could require Europe to introduce the appropriate changes to Certification Specifications before other NAAs.

comment *43* comment by: *Boeing*

QUESTION 2:
There has never been a fatality or serious injury in commercial aviation due to a volcanic eruption or ash encounter. Since the significant volcanic ash aviation related events of the 1980's and early 1990's, industry, led by ICAO, developed volcanic ash monitoring and warning systems for the aviation community, primarily through the VAACs. After the Eyjafjallajökull volcanic event of 2010, ICAO again, via the IVATF, enhanced operational and airspace control guidance and facilitated the implementation of VAAC best practices. Based on the safety record and the continuous improvements in operational guidance, monitoring, and forecasting, there would be no clear, objective-based safety benefit achieved by imposing a new certification standard. To certify an engine for a given amount of ash ingestion would add significant cost to the development and certification of the engine and could be potentially detrimental to the operating efficiency of the engine, which would make everyday operations less efficient and more costly, and produce greater emissions. Given the very successful safety and operational record, it is clear there is no justifiable benefit to imposing a new certification standard on turbine engines.

comment *44* comment by: *Boeing*

QUESTION 3:
Because of the international nature of aviation, a significant percentage of European traffic comes from outside European airspace; thus, ensuring safe and efficient airspace control must be coordinated globally. As Europe and the rest of the world enhance their volcanic ash detection, tracking, and forecasting capabilities, operational safety and efficiency will improve, whether conditions are IMC or not. Even with enhanced capabilities to detect and track volcanic ash, flight crews will need to continue to rely on their senses and follow their flight crew instructions to immediately exit volcanic ash if they discern they are in an ash cloud (e.g., acrid odor, static discharge around the windshield, smoke or dust

on the flight deck, etc.). This approach is no different from when a flight crew inadvertently gets into severe inclement weather or turbulence, i.e., they will try to exit it as quickly and safely as they can.
While there currently are several airborne ash detection devices available and others under development, none has been shown to be adequate to allow a flight crew to ignore when they discern they have encountered an ash cloud. Onboard detectors bring with them their own costs for maintaining the equipment, weight of carrying the equipment everyday or installing it when needed, flight crew training on how to use and interpret the output of these detectors, etc. These costs need to be weighed against the costs (and additional benefits) of enhanced remote ash cloud detection, tracking, and forecasting capabilities. While enhancing the capabilities in Europe to detect and track volcanic ash will potentially improve operational efficiency, imposing a volcanic ash standard for turbine engines will not provide any airborne operational flexibility, even in IMC conditions. While there is particularly high traffic density in Europe, other parts of the world have relatively high traffic density with significantly more volcanic activity and they are managing their operations safely and efficiently without volcanic ash certification standards for turbine engines.

comment *45* comment by: *Boeing*

QUESTION 4:
Engine certification requirements are currently essentially harmonized across global regulators. Introducing an EASA-unique design standard will have broader impact than just engines operated in Europe due to the need for common engines across the global fleet. EASA should weigh these broader impacts against the post-IVATF benefits.

comment *60* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 10 of 18
Question 2
Is there a clear, objective-based safety benefit that would be achieved by imposing a new certification standard?
ICCAIA Comment/Response on Question 2:
There has never been a fatality or serious injury in commercial aviation due to a volcanic eruption or ash encounter. Since the significant volcanic ash aviation related events of the 1980's and early 1990's, industry, led by ICAO, developed volcanic ash monitoring and warning systems for the aviation community, primarily through the VAACs. After the Eyjafjallajökull volcanic event of 2010, ICAO again, via the IVATF, enhanced operational and airspace control guidance and facilitated the implementation of VAAC best practices. Based on the safety record and the continuous improvements in operational guidance, monitoring, and forecasting, there would be no clear, objective-based safety benefit achieved by imposing a new certification standard. To certify an engine for a given amount of ash ingestion would add significant cost to the development and certification of the engine and could be potentially detrimental to the operating efficiency of the engine, which would make everyday operations less efficient and more costly, and produce greater emissions. Given the very successful safety and operational record, it is clear there is no justifiable benefit to imposing a new certification standard.

comment *74* comment by: *ICCAIA - International Coordinating Council of Aerospace*

Industry Associations

NPA Page 10 of 18
Question 3
Given the high traffic densities of European airspace and the frequent requirement for operation in IMC, and given also the enhanced capabilities in Europe to detect and track volcanic ash, should EASA propose a standard applicable only in European airspace?
ICCAIA Comment/Response on Question 3:
Because of the international nature of aviation, a significant percentage of European traffic comes from outside European airspace; thus, ensuring safe and efficient airspace control must be coordinated globally. As Europe and the rest of the world enhance their volcanic ash detection, tracking, and forecasting capabilities, operational safety and efficiency will improve, whether conditions are IMC or not. Even with enhanced capabilities to detect and track volcanic ash, flight crews will need to continue to rely on their senses and follow their flight crew instructions to immediately exit volcanic ash if they discern they are in an ash cloud (e.g., acrid odor, static discharge around the windshield, smoke or dust on the flight deck, etc.). This approach is no different from when a flight crew inadvertently gets into severe inclement weather or turbulence, i.e., they will try to exit it as quickly and safely as they can.
While there currently are several airborne ash detection devices available and others under development, none has been shown to be adequate to allow a flight crew to ignore when they discern they have encountered an ash cloud. Onboard detectors bring with them their own costs for maintaining the equipment, weight of carrying the equipment every day or installing it when needed, flight crew training on how to use and interpret the output of these detectors, etc. These costs need to be weighed against the costs (and additional benefits) of enhanced remote ash cloud detection, tracking, and forecasting capabilities. While enhancing the capabilities in Europe to detect and track volcanic ash will potentially improve operational efficiency, imposing a volcanic ash standard for turbine engines will not provide any airborne operational flexibility, even in IMC conditions. While there is particularly high traffic density in Europe, other parts of the world have relatively high traffic density with significantly more volcanic activity and they are managing their operations safely and efficiently without volcanic ash certification standards for turbine engines.

comment *75* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 10 of 18
Question 4
Is harmonisation of EASA standards with those of other States of Design (e.g. USA and Canada) of such importance in respect of volcanic ash that it should take priority over a solution for Europe?
ICCAIA Comment/Response on Question 4:
Engine certification requirements are currently essentially harmonized across global regulators. Introducing an EASA-unique design standard will have broader impact than just engines operated in Europe due to the need for common engines across the global fleet. EASA should weigh these broader impacts against the post-IVATF benefits.

comment *82* comment by: *IACA International Air Carrier Association*

Please find attached hereto the IACA input. With best regards Erik Moyson	A-NPA 2012-21 VA CS-E_IACA input.pdf

comment *86* comment by: *Vereinigung Cockpit e.V.*

Question 2
Yes. Present day operations deal with great uncertainty with respect to ash concentration forecasting. This is dealt with by individual operators ´SRA, assessed and approved by individual states´ authorities, and all in a quite intransparent way. It would enhance certainty, clarity of operations if a common standard will be introduced.
Question 3
Europe certainly has a high traffic volume, and IMC operations are quite frequent. It is far from certain that a highly developed ash detection capability exists; if this is to become part of the standard, the capability needs to be specified, built-up and verified. In any case, a standard applicable in airspace with enhanced ash detection and forecasting capability is desireable.
Specifications for the VA and SO2 detection and forecasting should, however, be universally applicable so as to enable in principle the Euro-Rules to be applied worldwide. Harmonization under the umbrella of ICAO should be a goal, but should not be a hindrance.
Question 4
If harmonization brings a benefit, then it should have priority, if it is only an obstacle to further development of aviation, and if it´s non-application would bring clear gains in Europe, then in should receive lower priority. An example is ACARS-X, where a system was developed quite far without any pretense at harmonization in the USA. This has now led to the adoption of this system into the SESAR plans for european air traffic control.

comment *104* comment by: *James Crotty, FAA*

COMMENT #6 of 13
Page: 10 of 18
Paragraph: X. The case for setting engine ash ingestion limits, Question 3
The proposed text states: *"Question 3 Given the high traffic densities of European airspace and the frequent requirement for operation in IMC, and given also the enhanced capabilities in Europe to detect and track volcanic ash, should EASA propose a standard applicable only in European airspace?"*
REQUESTED CHANGE: EASA should invite other safety agencies to participate in research activities. EASA should only consider future rulemaking after EASA has the corroborating data needed to show both safety and efficacy. Only then should EASA consider engaging in a harmonized effort to produce new regulatory material.
JUSTIFICATION: The FAA is aware of the strong interest the EU has to minimize the economic disruption of aviation transport in the event of a volcanic eruption. It is recommended that EASA support global harmonization of how services are provided so the information and decisions support process is transparent regardless of ICAO Region. This will ensure safe airplane operations without having to complicate international operations or compromise aviation safety.

comment *105* comment by: *James Crotty, FAA*

COMMENT #7 of 13
Page: 10 of 18
Para: X. The case for setting engine ash ingestion limits, Question 4
The proposed text states: *"Question 4 Is harmonisation of EASA standards with those of other States of Design (e.g. USA and Canada) of such importance in respect of volcanic ash that it should take priority over a solution for Europe?"*
REQUESTED CHANGE: No change in the regulations should be accomplished until the necessary research on the impact to airplane safety from exposure to volcanic ash and volcanic cloud constituents has been completed. In addition, EASA should invite other safety agencies to participate in the research activities. The FAA would support the research effort.
JUSTIFICATION: EASA should continue to work with other aviation authorities to research all aspects of volcanic ash and its effects on aircraft, and if the research advances the state-of-knowledge sufficiently and if justified.

comment *113* comment by: *James Crotty, FAA*

X. The case for setting engine ash ingestion limits (p. 10 of 18)
Question 2
Is there a clear, objective-based safety benefit that would be achieved by imposing a new certification standard?
The safety benefit must be evaluated on a risk vs. safety benefit basis. Without some sort of balance between safety and risk, these proposed certification standards can impose unwarranted costs and impose design features that may be counter to fuel efficiency and environmental air quality gains. Historically the "avoid-avoid-avoid" perspective of volcanic ash cloud avoidance has proven to offer the maximum flexibility to Operators while retaining an acceptable safety record. The recently issued ICAO Doc 9974 has reinforced the Operator's regulatory requirement to assure flight safety using an SRA as part of their risk-benefit analysis. While the FAA has initiated a program to test engine tolerance for ash it will be limited in scope and will not be able to address engine tolerance for every aircraft type/engine. Thus while there will be more data it will not all be inclusive; and therefore, each operator's SRA will still be of paramount importance to maintain safety of flight without certification standards.
Question 3
Given the high traffic densities of European airspace and the frequent requirement for operation in IMC, and given also the enhanced capabilities in Europe to detect and track volcanic ash, should EASA propose a standard applicable only in European airspace?
This suggestion is counter the principals of global harmonization to ensure seamless international aviation commerce. It is also counter to ICAO principals of agreeing on international safety standards. The U.S. and other States fully recognize the challenges of operating in high density airspace thus it is imperative that any standards developed in Europe can be applicable in other ICAO Regions. This can best be accomplished via consensus rather than rulemaking. Europe and its international partners would be better served by continuing to enhance and improve the ash detection and forecast capabilities to more precisely identify where ash exists, within three dimensional airspace, and to accurately forecast its movement. Operators can then utilize the maximum available clear airspace for continued flight operations without undue risk to the flying public.
Question 4
Is harmonisation of EASA standards with those of other States of Design (e.g. USA and Canada) of such importance in respect of volcanic ash that it should take priority over a solution for Europe?
International standards harmonization is crucial for both commerce and safety.

Additionally, international oceanic airways are controlled by multiple countries' air traffic control organizations. Un-harmonized regulations can disrupt the smooth flow of international air traffic and cause confusion amongst flight crews. Additionally, it is not clear if applying ash ingestion airworthiness standards would even offer a "solution for Europe" (quote). Potentially, these proposed airworthiness standards could result in a lower level of safety resulting from the Operators inappropriately assuming unwarranted aircraft and engine operational capability in an ash environment, and knowingly flying into ash contaminated airspace, thereby risking passenger safety.

B. Possible courses of action — XI. Challenges associated with volcanic ash testing and in defining engine limits -

comment *106* comment by: *James Crotty, FAA*

COMMENT #8 of 13
Page: 11 of 18
Paragraph: XI. Challenges associated with volcanic ash testing and in defining engine limits 40.
The proposed text states: *"40. There are a number of challenges associated with engine testing and defining engine volcanic ash limits. A non-exhaustive list is provided below that lists some of these issues:*
….
Research needs."
REQUESTED CHANGE: It is recommended that EASA withdraw this A-NPA until the necessary research on the total effect of continuous flight in an atmosphere contaminated with volcanic ash and volcanic cloud constituents is completed.
JUSTIFICATION: The FAA agrees that approval for continuous flight through an atmosphere contaminated with low levels of volcanic ash and volcanic cloud constituents will require an assessment of the impact on all aspects of airplane safety.

comment *6* comment by: *EUROCOPTER*

Eurocopter's answer to Question 5:
For the moment, sand seems to be the only reference or similarity with ash that the aeronautics industry may use. Eurocopter has used that experience about sand protection (kits of protections, cautions in case of exposure, …) to make the SIN2197-S-00-REV2 (Safety Information Notices) for its operators just after the 2010 Eyjafjallajökull volcanic eruption.
Nevertheless, this type of similarity is a first approach, so that all the ash effects may not be simulated correctly with sand.

comment *7* comment by: *EUROCOPTER*

Eurocopter's answer to Question 6:
Research for the definition of the characteristics of the threat (VA)

Research on engine behaviour to VA cloud contamination

VA airborne detection equipment and/or a ground detection system network linked to aircraft

Development of Accepted Means of Compliance and Guidance Material

Engine health monitoring

Detail: Eurocopter considers that the requirement for identification of an immunity level cannot be fulfilled if the threat itself is not clearly described for all its characteristics which are necessary to assess potential hazardous situation on the helicopter operation. Presently any assessment would not be possible in practice since it does not even provide only concentration values, which is by far insufficient. Moreover, according to Industry knowledge regarding sand and dust various effects, at least particles size and roughness would need also to be provided, but it may also be other aspects as temperatures….When such description will be given in the rule, it should then be possible to develop advisory materials and test method which would provide for well acknowledged and standardized method for establishing the immunity level of helicopter against volcanic ashes. Such development would require involvement of industry, authorities and research offices into an international regulatory research program**.**

comment *8* comment by: *EUROCOPTER*

Eurocopter's answer to Question 7:
Remote detection of ash particles or vapors, either on-board or else a connection with a ground detection system network (shared with other aircraft, airports, …), would be the ideal equipment in order to provide alerts, and a help for rerouting or mission aborting.
However, this type of system is certainly not available, and would need some efforts for validation, before implementation, as a kit.
If such equipment were really efficient and reliable, assessments of ash effects on rotorcraft (engine, …) and protections might not be necessary, and such a kit would become mandatory to fly in case of ash alert.

comment *9* comment by: *EUROCOPTER*

Eurocopter's answer to Question 8:
Negative impacts on fuel consumption, required maintenance actions and engine cost have to be minimized in priority. An acceptable compromise will depend on the figures.

comment *10* comment by: *EUROCOPTER*

Eurocopter's answer to Question 9:
Question is specific to engine manufacturers.

comment *11* comment by: *EUROCOPTER*

Eurocopter's answer to Question 10:
Question is specific to engine manufacturers.

comment *12* comment by: *EUROCOPTER*

Eurocopter's answer to Question 11:
Question is specific to engine manufacturers.

comment *13* comment by: *EUROCOPTER*

Eurocopter's answer to Question 12:
Yes this option deserves to be investigated.

comment *22* comment by: *DGAC France*

Question 5:
Sand testing does not necessarily have any added value in predicting turbine engines' robustness in areas contaminated by volcanic ash. If the sand used during experiments doesn't represent volcanic ashes in a satisfactory manner (granularity, chemical composition, level of silica, melting point, …) , sand testing is of no interest.

Question 6:
Research led on turbine engines' susceptibility in areas contaminated by volcanic ashes should be promoted. Manufacturers, engine designers and operators should be associated in establishing what would merit prioritisation.

Question 7:
On-board equipment should improve real-time information provided to the crew about the presence of volcanic ash clouds and their characteristics. Nevertheless, if this equipment was to be required at design level, its added value would be limited.

comment *23* comment by: *DGAC France*

Question 8:
The French DGAC does not want a Certification Specification to be introduced.

Question 9:
The French DGAC does not want a Certification Specification to be introduced.

Question 10:
This question concerns engine TC holders.

Question 11:
Generic module testing should improve the knowledge of turbine engines' robustness while reducing the number of effective tests during certification.

Question 12:
Operator's SRA will be more operational and homogeneous if the data they rely on is more precise. In particular, clarifications on which maintenance operations should be considered according to the type of exposition experienced by the engines would be surely appreciated by operators. However, the proactive adaptation of flight operations concerning safety hazards requires a better accuracy in volcanic ash clouds forecasts, density measurements and ash characteristics models. Without any real progress in these fields, it seems illusionary to expect a pertinent use of the economic region by operators in order to allow them a greater operational flexibility.

comment *29* comment by: *UK CAA*

Page No: 12 of 18

Paragraph No: Question 5: Could sand testing provide any benefit to enhance the information available to operators for use within their VA SRAs?
Comment: Sand testing could be of limited use in understanding the degradation effects of operating in a VA environment, although some useful compressor blade erosion data could be obtained and possibly be of some use.
Justification: Sand testing would not simulate the glassing effects of VA particles melting in the combustor, fuel nozzle and turbine areas, which has been found to be the significant degradation factor in high density ash events.

comment *30* comment by: *UK CAA*

Page No: 12 of 18
Paragraph No: Question 6: What activities could be considered in this context and which would merit prioritisation?
Comment: The industry would benefit from greater knowledge of the effects of ash contamination when operating in a dispersed VA environment, after some development testing has been carried out to date. For this reason, testing of the following areas should be considered;
a) Gas turbine ash ingestion testing representative of modern GT engines in terms of elevated TGTs (turbine gas temperatures) and reduced surge margins etc.
b) Predictive ash dispersion forecasting models.
c) In flight ash detection sensor equipment, installed on aircraft.
d) Real time and enhanced engine health monitoring.
Justification: All of the above listed activities have the potential to improve safe operations in a dispersed ash environment, however, some of these are in early stages of development and would benefit from some formalised research and development. The capability of measuring ash concentrations and durations on board commercial aircraft operating in dispersed ash environments could assist operators to monitor exposure to ash and enhance safe operations under a safety risk assessment (SRA).

comment *31* comment by: *UK CAA*

Page No: 12 of 18
Paragraph No: Question 7: What characteristics would on-board equipment need to have in order to deliver significant operational benefit?
Comment: The operational and reliability requirements for any on-board equipment used would have to be defined and the benefits clearly established. The criticality for operation in ash contaminated environments, and hence the qualification process to be used for such systems would also have to be clearly defined.
Justification: Part of the certification of any on-board equipment would have to assess the safety benefit and the qualification process necessary.

comment *32* comment by: *UK CAA*

Page No: 13 of 18
Paragraph No: Question 8: The introduction of a Certification Specification may drive engine manufacturers to design an ash tolerant engine that detrimentally impacts emissions, fuel burn, required maintenance actions and cost. What would be an acceptable compromise to stakeholders?
Comment: If the CS were to make a declaration of capability (in terms of operability in dispersed low ash concentration environments) rather than meeting a clear design specification, then it is unlikely to compromise design targets

regarding emissions, fuel burn etc.
Justification: Making a design declaration regarding operations in dispersed ash are unlikely to affect other design criteria, unless perhaps, there are intentions to make engines more ash tolerant.

comment *33* comment by: *UK CAA*

Page No: 13 of 18
Paragraph No: **Question 9**: Can a certification test be adequately defined to address a globally acceptable requirement?
Comment: Based on internationally agreed scientific knowledge and generally accepted criteria such as volcanic ash composition, concentration levels and possibly duration should be utilised in this proposed CS. Some guidelines on volcanic ash composition have been specified in the International Volcanic Ash Task Force 2nd (IVATF/2) meeting in Appendix 2B, and these should be utilised in clarifying a future certification test. If the CS were to make an ash tolerance declaration for new engines, then this declaration can be applied globally as necessary or as possible. Similarly a CS declaration can be applied purely in the European airspace environment to enhance SRAs.
Justification: Internationally accepted guidelines in IVATF/2 have already been accepted as a starting point for a VA composition specification. The CS operability declaration option provides the greatest flexibility for global acceptance.

comment *34* comment by: *UK CAA*

Page No: 13 of 18
Paragraph No: **Question 10**: Have engine TC holders already foreseen the need to undertake specific engine volcanic ash testing? If so, can you give details of the test specification to be used?
Comment: Question appears to be addressed to TC Holders.
Justification: Question not applicable to NAAs.

comment *35* comment by: *UK CAA*

Page No: 13 of 18
Paragraph No: **Question 11**: What benefits could generic module testing produce and would those benefits merit taking this work forward?
Comment: This approach could be useful in establishing the resilience of some in-service designs, but would need to be accepted by all major engine TC Holders to have some benefit.
Justification: There appears to be insufficient information available on the subject of turbine engine volcanic ash ingestion at lower ash concentration levels.

comment *36* comment by: *UK CAA*

Page No: 13 of 18
Paragraph No: **Question 12**: Would such information offer benefits sufficient to merit taking this work forward?
Comment: This could provide some useful theoretical data that could establish the resilience of gas turbine engines currently in service, particularly in the area of VA ingestion at the lower ash concentrations, of the type predicted in the 2010/2011 Icelandic volcano eruptions.
Justification: There appears to be insufficient information available on the

subject of turbine engine volcanic ash ingestion at lower ash concentration levels.

comment *46* comment by: *Boeing*

OPTION 1: Sand Testing (p. 12 of 18)
Question 5
Could sand testing provide any benefit to enhance the information available to operators for use within their VA SRAs?
Sand testing would not provide any substantial beneficial information not already available to operators. Current turbine engine designs incorporate an appropriate robustness for operation in dusty, dirty, sandy environments. Engine manufacturers continue to gain experience as their engines are exposed to environmental factors, such as sand, and adjust their current maintenance recommendations or develop new ones to allow reliable, cost effective operations. Sand is not generally considered to be representative of volcanic ash due to the differences in composition and particle size. Additional sand testing would not materially contribute to the existing information available to operators to make the safety risk assessment on where or if to fly during a volcanic ash event.

comment *47* comment by: *Boeing*

Option 2: Research programme (p. 12 of 18)
Question 6
What activities could be considered in this context and which would merit prioritisation?
If further research were to be considered, it is recommended that it should be conducted through **WE**ather ha**ZARD**s for Aeronautics (WEZARDs) or another similar forum. The priority for this should be an assessment of likely future disruption when operating within the guidance developed by IVATF and in use today. This should account for expected volcanic activity and improvements in measurement and forecasting. A level of disruption that would be socially and economically acceptable would need to be identified and the most realistic and cost effective programme to achieve that acceptable level of disruption established. The need for any future certification requirements for engine or airframe should be based on the knowledge gained from these programmes.
As a part of this overall research activity, engine testing, such as that being developed by the U.S. government via a project known as Vehicle Integrated Propulsion Research (VIPR3), will provide solid scientific knowledge basis for policy, strategy, and decisions. This testing, or testing sponsored by EASA, will expand industry's understanding of turbine engine susceptibility to volcanic ash or improve maintenance programs. This type of testing could also lead to better information for operators to make their safety risk decisions when considering operations in the event of a volcanic eruption and subsequent ash cloud.

comment *48* comment by: *Boeing*

Option 2: Research programme (p. 12 of 18)
Question 7
What characteristics would on-board equipment need to have in order to deliver significant operational benefit?
It is unclear if equipping every aircraft with an "ash-detector" is the most effective, cost efficient, or practical approach to dealing with operations during a volcanic ash event. As previously indicated, even with a highly accurate reliable

on-board "ash-detector," the flight crew would still avoid operation in an ash cloud, just like they would not continue to operate in severe weather or turbulence. On-board equipment could have value, specifically if used on non-revenue exploratory aircraft to validate the location of a volcanic ash cloud and to help improve the forecast models and operational planning. Continuing research on airborne volcanic ash detectors is one of several research areas that will be beneficial for enhancing operational safety and efficiency during a volcanic ash cloud event.
EASA should consider initiating or supporting airborne volcanic ash detectors as part of its mission to manage safety research projects needed to provide the Agency with a solid scientific knowledge basis for its policy, strategy, and decisions. As the reliability, accuracy, and capability of on-board "ash detectors" improve, operators will assess their operational benefits and adjust their safety risk assessments accordingly. Once these technologies have proven themselves, similar to other technologies such as ACAS, TAWS, RVSM, ADS-B, or Data Link, the need for more uniform regulatory or operational guidance will need to be re-evaluated.

comment *49* comment by: *Boeing*

Option 3: New Certification Specification in CS-E ***(p. 12-13 of 18)***
Question 8
The introduction of a Certification Specification may drive engine manufactures to design an ash tolerant engine that detrimentally impacts emissions, fuel burn, required maintenance actions and cost. What would be an acceptable compromise to stakeholders?
The great advantage of the ICAO-sponsored IVATF was that all stakeholders from Volcanic Ash Advisory Centers and meteorological offices, type design certification authorities, and aircraft and engine design/manufacturers were involved in the process, and provided comprehensive, sensible recommendations after their two years of intense work. IVATF considered experience from across the globe, including areas of high aviation traffic such as European airspace. None of the accomplishments or recommendations of the IVATF indicates that certification specifications for turbine engines would provide any tangible quantitative improvement in flight safety or efficiency during a volcanic ash cloud event. Certification Specifications would drive engines to be less fuel efficient, creating more emissions, and more expensive to operate and maintain. If the CS causes engines to be even one-percent less efficient, it would create approximately 22 million more tons of CO_2 every year for flights to and from Europe (based on Emissions Trading Scheme data from the European Commission). These emissions would be created every day, regardless of whether or not there was a volcanic ash event, and would not eliminate the need for the flight crew to exit a discernible ash encounter. There would be even more CO_2 generated globally, as the implementation would not be regional, but across the entire fleet.

comment *50* comment by: *Boeing*

Option 3: New Certification Specification in CS-E ***(p. 12-13 of 18)***
Question 9
Can a certification test be adequately defined to address a globally applicable requirement?
Our technical assessment is that it is not currently possible to adequately define a certification test due to the large number of variables, such as volcanic ash composition and likely particle size. Furthermore, the variation in engine designs

across the global fleet would amplify the challenge. The best way to answer this question is for EASA to initiate or support an overall research programme, as outlined in the response to Question 6. This may include volcanic ash engine testing, as part of its mission to manage safety research projects needed to provide the Agency with a solid scientific knowledge basis for its policy, strategy, and decisions. Writing a certification specification and hoping that, once it is written, EASA or the engine manufacturers will be able to figure out what it takes to meet the certification specification, is contrary to EASA's stated mission; it is a recipe for focusing regulatory and industry efforts away from other areas that have a more significant influence on safety and efficient operations.

comment 51 comment by: *Boeing*

Option 3: New Certification Specification in CS-E ***(p. 12-13 of 18)***

Question 10

Have engine TC holders already foreseen the need to undertake specific engine volcanic ash testing? If so, can you give details of the test specification to be used?

Engine manufacturers are participating and supporting the U.S.-sponsored turbine engine volcanic ash ingestion testing (VIPR3). The intent of this research is to gain basic knowledge for developing policy, strategy, and decisions. This testing is assessing the type of ash that might be most appropriate and reasonably available to use in the test, how to ingest the ash into an engine, how to control the engine during the test to obtain the most useful information, and then evaluating potential operational techniques and maintenance actions.

comment 52 comment by: *Boeing*

Option 4: Generic module testing ***(p. 13 of 18)***

Question 11

What benefits could generic module testing produce and would those benefits merit taking this work forward?

From a research perspective, module testing should be considered. However, as stated previously, setting certification standards without first conducting appropriate research is in contradiction to EASA's mission to gain a solid scientific knowledge basis for its policy, strategy, and decisions. EASA should initiate or support research via WEZARDs or other forums to gain fundamental knowledge with which they can develop their decisions on future action. In addition, a difficulty in merging the results of module testing may come from the individual knowledge of each OEM that may result in a given engine module being more or less sensitive to volcanic ash, depending on specific proprietary technology applied (e.g. anti-erosion blade coating).

comment 53 comment by: *Boeing*

Option 5: Business case (Level of volcanic ash exposure set by the operator)
(p. 13 of 18)

Question 12

Would such information offer benefits sufficient to merit taking this work forward

Essentially, the operators today are setting their own economic exposure standards based on operations within the OEM's recommendations and their own experience and expertise. The OEMs have already provided operators with their

accumulated experience from the broader fleet. Each operator has to consider many factors when they make their decision to operate during a volcanic ash event:
- first and foremost, flight safety,
- the economic impact of not flying or flying in a region with low, but non-visible or discernible ash, and
- the accuracy and timeliness of volcanic ash cloud information

These decisions are the responsibility and prerogative of the operators. ICAO has created Doc 9974, "*Flight Safety and Volcanic Ash - Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination,*" to help assist operators and their regulatory authorities make these determinations. EASA's recommendation for European operators, in their Safety Information Bulletin 2010-17 -- to use the recommendations of ICAO Doc 9974 combined with the establishment of Volcanic Ash Advisory Centers best practices -- will significantly enhance the safety and efficiency of operation throughout Europe.
In addition, the "exposure" cannot be easily defined by a single number (concentration) or combination of numbers (such as concentration and duration) because, as stated in the A-NPA section VIII. paragraph 32, there are a number of influencing factors. Hence, it might be impractical to define a suitable "monitoring factor" based on "exposure" and enabling operators to trigger adequate maintenance action, meaning little progress compared to current OEMs' recommendations.

comment *61* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 12 of 18
OPTION 1: Sand Testing
Question 5
Could sand testing provide any benefit to enhance the information available to operators for use within their VA SRAs?
ICCAIA Comment/Response on Question 5:
Sand testing would not provide any substantial beneficial information not already available to operators. Current turbine engine designs incorporate an appropriate robustness for operation in dusty, dirty, sandy environments. Engine manufacturers continue to gain experience as their engines are exposed to environmental factors, such as sand, and adjust their current maintenance recommendations or develop new ones to allow reliable, cost effective operations. Sand is not generally considered to be representative of volcanic ash due to the differences in composition and particle size. Additional sand testing would not materially contribute to the existing information available to operators to make the safety risk assessment on where or if to fly during a volcanic ash event.

comment *62* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 12 of 18
Option 2: Research Program
Question 6
What activities could be considered in this context and which would merit prioritisation?
ICCAIA Comment/Response on Question 6:
If further research were to be considered, it is recommended that it should be conducted through **WE**ather ha**ZARD**s for Aeronautics (WEZARDs) or another

similar forum. The priority for this should be an assessment of likely future disruption when operating within the guidance developed by IVATF and in use today. This should account for expected volcanic activity and improvements in measurement and forecasting. A level of disruption that would be socially and economically acceptable would need to be identified and the most realistic and cost effective programme to achieve that acceptable level of disruption established. The need for any future certification requirements for engine or airframe should be based on the knowledge gained from these programmes.
As a part of this overall research activity, engine testing, such as that being developed by the U.S. government via a project known as Vehicle Integrated Propulsion Research (VIPR3), will provide solid scientific knowledge basis for policy, strategy, and decisions. This testing, or testing sponsored by EASA, will expand industry's understanding of turbine engine susceptibility to volcanic ash or improve maintenance programs. This type of testing could also lead to better information for operators to make their safety risk decisions when considering operations in the event of a volcanic eruption and subsequent ash cloud.

comment *64* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 12 of 18
Option 2: Research Program
Question 7
What characteristics would on-board equipment need to have in order to deliver significant operational benefit?
ICCAIA Comment/Response on Question 7:
It is unclear if equipping every aircraft with an "ash-detector" is the most effective, cost efficient, or practical approach to dealing with operations during a volcanic ash event. As previously indicated, even with a highly accurate reliable on-board "ash-detector," the flight crew would still avoid operation in an ash cloud, just like they would not continue to operate in severe weather or turbulence. On-board equipment could have value, specifically if used on non-revenue exploratory aircraft to validate the location of a volcanic ash cloud and to help improve the forecast models and operational planning. Continuing research on airborne volcanic ash detectors is one of several research areas that will be beneficial for enhancing operational safety and efficiency during a volcanic ash cloud event.
EASA should consider initiating or supporting airborne volcanic ash detectors as part of its mission to manage safety research projects needed to provide the Agency with a solid scientific knowledge basis for its policy, strategy, and decisions. As the reliability, accuracy, and capability of on-board "ash detectors" improve, operators will assess their operational benefits and adjust their safety risk assessments accordingly. Once these technologies have proven themselves, similar to other technologies such as ACAS, TAWS, RVSM, ADS-B, or Data Link, the need for more uniform regulatory or operational guidance will need to be re-evaluated.

comment *65* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 12/13 of 18
Option 3: New Certification Specification in CS-E
Question 8
The introduction of a Certification Specification may drive engine

manufactures to design an ash tolerant engine that detrimentally impacts emissions, fuel burn, required maintenance actions and cost. What would be an acceptable compromise to stakeholders?

ICCAIA Comment/Response on Question 8:

The great advantage of the ICAO-sponsored IVATF was that all stakeholders from Volcanic Ash Advisory Centers and meteorological offices, type design certification authorities, and aircraft and engine design/manufacturers were involved in the process, and provided comprehensive, sensible recommendations after their two years of intense work. IVATF considered experience from across the globe, including areas of high aviation traffic such as European airspace. None of the accomplishments or recommendations of the IVATF indicates that certification specifications for turbine engines would provide any tangible quantitative improvement in flight safety or efficiency during a volcanic ash cloud event. Certification Specifications would drive engines to be less fuel efficient, creating more emissions, and more expensive to operate and maintain. If the CS causes engines to be even one-percent less efficient, it would create approximately 22 million more tons of CO_2 every year for flights to and from Europe (based on Emissions Trading Scheme data from the European Commission). These emissions would be created every day, regardless of whether or not there was a volcanic ash event, and would not eliminate the need for the flight crew to exit a discernible ash encounter. There would be even more CO_2 generated globally, as the implementation would not be regional, but across the entire fleet.

comment *66* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 12/13 of 18

Option 3: New Certification Specification in CS-E

Question 9

Can a certification test be adequately defined to address a globally applicable requirement?

ICCAIA Comment/Response on Question *9:*

Our technical assessment is that it is not currently possible to adequately define a certification test due to the large number of variables, such as volcanic ash composition and likely particle size. Furthermore, the variation in engine designs across the global fleet would amplify the challenge. The best way to answer this question is for EASA to initiate or support an overall research programme, as outlined in the response to Question 6. This may include volcanic ash engine testing, as part of its mission to manage safety research projects needed to provide the Agency with a solid scientific knowledge basis for its policy, strategy, and decisions. Writing a certification specification and hoping that, once it is written, EASA or the engine manufacturers will be able to figure out what it takes to meet the certification specification, is contrary to EASA's stated mission; it is a recipe for focusing regulatory and industry efforts away from other areas that have a more significant influence on safety and efficient operations.

comment *67* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 12/13 of 18

Option 3: New Certification Specification in CS-E

Question 10

Have engine TC holders already foreseen the need to undertake specific engine volcanic ash testing? If so, can you give details of the test

specification to be used?
ICCAIA Comments/Response on Question 10*:*
Engine manufacturers are participating and supporting the U.S.-sponsored turbine engine volcanic ash ingestion testing (VIPR3). The intent of this research is to gain basic knowledge for developing policy, strategy, and decisions. This testing is assessing the type of ash that might be most appropriate and reasonably available to use in the test, how to ingest the ash into an engine, how to control the engine during the test to obtain the most useful information, and then evaluating potential operational techniques and maintenance actions.

comment *68* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 13 of 18
Option 4: Generic module testing
Question 11
What benefits could generic module testing produce and would those benefits merit taking this work forward?
ICCAIA Comment/Response on Question 11:
From a research perspective, module testing should be considered. However, as stated previously, setting certification standards without first conducting appropriate research is in contradiction to EASA's mission to gain a solid scientific knowledge basis for its policy, strategy, and decisions. EASA should initiate or support research via WEZARDs or other forums to gain fundamental knowledge with which they can develop their decisions on future action. In addition, a difficulty in merging the results of module testing may come from the individual knowledge of each OEM that may result in a given engine module being more or less sensitive to volcanic ash, depending on specific proprietary technology applied (e.g. anti-erosion blade coating).

comment *69* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 13 of 18
Option 5: Business case (Level of volcanic ash exposure set by the operator)
Question 12
Would such information offer benefits sufficient to merit taking this work forward
ICCAIA Comment/Response on Question 12:
Essentially, the operators today are setting their own economic exposure standards based on operations within the OEM's recommendations and their own experience and expertise. The OEMs have already provided operators with their accumulated experience from the broader fleet. Each operator has to consider many factors when they make their decision to operate during a volcanic ash event:
· - first and foremost, flight safety,
· - the economic impact of not flying or flying in a region with low, but non-visible or discernible ash, and
· - the accuracy and timeliness of volcanic ash cloud information
These decisions are the responsibility and prerogative of the operators. ICAO has created Doc 9974, *"Flight Safety and Volcanic Ash - Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination,"* to help assist operators and their regulatory authorities make these determinations. EASA's

recommendation for European operators, in their Safety Information Bulletin 2010-17 -- to use the recommendations of ICAO Doc 9974 combined with the establishment of Volcanic Ash Advisory Centers best practices -- will significantly enhance the safety and efficiency of operation throughout Europe.
In addition, the "exposure" cannot be easily defined by a single number (concentration) or combination of numbers (such as concentration and duration) because, as stated in the A-NPA section VIII. paragraph 32, there are a number of influencing factors. Hence, it might be impractical to define a suitable "monitoring factor" based on "exposure" and enabling operators to trigger adequate maintenance action, meaning little progress compared to current OEMs' recommendations.

comment *81* comment by: *Snecma*

Extracts from letter YES 492-13-MH attached in General Section :

Snecma has provided the following inputs to the ICCAIA answers

Answer to Question 11 (13 of 18)
A difficulty in merging the results of module testing may come from the individual knowledge of each OEM that may result in a given engine module being more or less sensitive to volcanic ash depending on specific proprietary technology applied (e.g. anti-erosion blade coating).

Answer to Question 12 (13 of 18)
The "exposure" cannot be easily defined by a single number (concentration) or combination of numbers (such as concentration and duration) because, as stated in A-NPA Section VIII. Paragraph 32, there are a number of influencing factors. Hence it might be impractical to define a suitable "monitoring factor" based on "exposure" and enabling operators to trigger adequate maintenance action, meaning little progress compared to current OEMs' recommendations.

comment *87* comment by: *Vereinigung Cockpit e.V.*

The regulator and authorities should have more knowledge about VA!

comment *88* comment by: *Vereinigung Cockpit e.V.*

Question 5
In view of the fact that volcanic ash obtained from deposits found on the ground near or at some distance from volcanos is very probably more representative of airborne volcanic ash, testing aircraft engines with sand only is not considered adequte.

Question 6
Engine VA and SO2 ingestion testing is one high-priority activity, as less data are available. Defining standards without test – data is fraught with high margins of residual error. As this is not desireable, engine tests should be done.
Development of real-time ash detection equipment is another high-priority activity. Engine health monitorig is already quite advanced, and it is believed that the engine – data transmitted routinely for maintenance purposes should already be able to provide some information with regards to serious performance issues.
Question 7
Requirements properties of on-board VA and SO2 detection equipment should be

determined by research. Equipment, that enables avoidance action to be taken by pilots would be much preferable to equipment that does only detect ash impinging on the aircraft.

comment *89* comment by: *Vereinigung Cockpit e.V.*

Question 8
VA and SO2 should not be the primary design parameters of engines. A level of VA and SO2 resistance is, however, definitely a desireable design property if feasible. It would be acceptable if part of the on-going improvement of engine-design with regards to emissions, fuel burn, maintenance and cost is traded off against an increased level of VA and SO2. It should be noted that some of these cost is offsett by gains for the operator and society as dependability and safety of air travel is increased.
Question 9
It should be possible to design adequate test scenarios. Full scale tests on engines encountering simulated dust resulting from nuclear detonations have been run in the USA, and testing for dust is a regular, well defined industrial activity. A variety of stadards are known to exist, like Mil STD 810 and SAE standards.
Question 10
To be answered by TC holders.

comment *90* comment by: *Vereinigung Cockpit e.V.*

Question 11
Such model - testing could result in economic and time-efficiencies to be realized. Test-results could be available earlier and at less cost than would otherwise be the case. The time-argument alone might merit exploring this option, however, care has to be taken to ensure applicability of results to the specific engine / product.
Question 12
The definition used in the question isn´t very well defined. The definition of the upper limit (see page 8) seems for our experience far to high – minimum one order of magnitude.
In principle, the idea has merit, but it remains to be seen if the test - procedures to be estabilished and the results obtain enable implementation.

comment *95* comment by: *British Airways*

Q.6 Research into a greater understanding of the effects of ash on the components of the turbine engine should be undertaken. The industry understanding of the impacts on ash on turbine engines is based on a few in service events and limited testing. The establishment of a globally co-ordinated approach would be welcomed. Collaboration between Europe and the USA would be a sensible starting point for this. The USA, under the VIPR4 project, should be supported.
Q 7. Onboard equipment would need to be able to establish a in-flight quantitative reading that is relevant to any certified threshold. It must be able to provide the operating crew with a warning with enough time to avoid that area. It must be able to show to the crews a flightpath that would comply with any threshold restriction defined by the OEM.
Q.8 The relative frequency and cost of the impact of ash events would have to be balanced against the increase in fuel cost over the service life of an engine/airframe combination. The negative impact on the overall economy (across

Europe) of a severe event cannot be bourne through an increase in fuel consumption and associated costs to the operators.

comment *107* comment by: *James Crotty, FAA*

COMMENT #9 of 13
Page: 11 of 18
Paragraph: XII. Options identified 44
The proposed text states: *"…. Option 0: Do nothing*
As part of an operator's SRA, advice from engine and airframe TC holders is sought regarding the susceptibility of their products for operation in airspace contaminated with volcanic clouds. This advice has been to avoid flight in known ash concentrations above 2 mg/m^3, or in ash that is visible to the naked eye or otherwise detectable by the crew (smell, St Elmo's fire, etc.). If an aircraft encounters volcanic ash in flight, then the flight crew is expected to vacate the contaminated airspace as safely and expeditiously as possible, as soon as they are alerted to the hazard. This advice has been largely established based on service experience, limited analysis, and engineering judgment. It presumes that the encounter with ash will normally be avoidable, but that if avoidance fails the aircraft will continue to be at a level of airworthiness where safe continued flight and landing is assured.
Unless engines are certified to a specific tolerance level, it would be necessary to continue with this approach."
REQUESTED CHANGE: It is recommended that EASA withdraw this A-NPA until the necessary research on the total effect of continuous flight in an atmosphere contaminated with volcanic ash and volcanic cloud constituents is completed. As part of this research, the FAA recommends that human health inhalation studies be completed, as we expect occupant safety to potentially result in lower concentration limits than those acceptable to airplane, mechanical and electrical systems, and powerplant.
JUSTIFICATION: The FAA believes that in order to accurately assess the risk to airplane safety, research must first be completed on the adverse impact to airplane, mechanical and electrical systems, powerplant and occupant health from continuous flight through an atmosphere contaminated with volcanic ash and volcanic cloud constituents. Also, FAA anticipates that the physiological limits to ensure occupant safety may potentially result in lower acceptable concentration limits; therefore, FAA recommends that the adverse physiological risk must be properly evaluated as part on this initial research.

comment *108* comment by: *James Crotty, FAA*

COMMENT #10 of 13
Page: 12 of 18
Paragraph: XII. Options identified 45
The proposed text states: *"… Option 1: Sand testing*
In the short term, option 0 could be supplemented by the systematic use of sand testing to support the analysis and in-service experience of volcanic ash. It is recognised that this option would provide some limited use with respect to erosion of blades and vanes, but would not provide valid representation of molten ash during engine testing.
Question 5 Could sand testing provide any benefit to enhance the information available to operators for use within their VA SRAs?
REQUESTED CHANGE: Testing with sand may provide useful data for assessing the impact on some systems provided that the properties of the sand are

representative of volcanic particulate material.
JUSTIFICATION: Testing with sand may provide useful data for assessing the impact on some systems provided that the properties of the sand are representative of volcanic particulate material (e.g., hardness, abrasion characteristics, mean aerodynamic diameter(s) of the distribution of material, magnetic properties, etc). This should be determined by a team of geologists and volcanologists. Additional component testing for the effect of specific properties (e.g., chemical reactivity, electrical conductivity, etc) may be required to argument the sand testing.

comment *109* comment by: *James Crotty, FAA*

COMMENT #11 of 13
Page: 12 of 18
Paragraph: XII. Options identified 46
The proposed text states: *"…. Option 2: Research programme*
Identify a set of activities, potentially including engine research testing, to gain improvements in, or better understanding of, factors that influence the uncertainty of SRAs. This might lead to a more robust regime. It would not include additional Certification Specifications. It could include improved health monitoring.
Advances in volcanic ash airborne detection and engine health monitoring technology could be used together to assess both the short-term and long-term hazards of volcanic ash, in real time. The installation of volcanic ash (VA) detection equipment may allow flights into known areas of VA, provided the identified density is below the level at which immediate safety of flight is a concern, including a margin of safety. Engine health monitoring may be used to establish the continued airworthiness of the engines, including providing advice to maintenance staff (and possibly the flight crew) of incipient failures. This may be an option for currently certified engine designs.
Question 6 What activities could be considered in this context and which would merit prioritisation?
Question 7 What characteristics would on-board equipment need to have in order to deliver significant operational benefit?"
REQUESTED CHANGE: It is recommended that EASA withdraw this NPA until the necessary research on the impact to total airplane safety from volcanic ash and volcanic cloud constituents has been completed.
In response to question 7, the presence of sensors must be reliable and accurate and be capable of providing a sufficiently early enough alert to the flight crew in the event volcanic ash and volcanic cloud constituents are detected during all normal airplane flight operations, that the crew can react to avoid harmful ash clouds. We anticipate that the sensors must provide the flight deck crew with notification at least several minutes before entering an ash cloud and it should be capable of detecting volcanic ash and other volcanic cloud constituents. In addition there appears to be an inherent assumption in the use of onboard sensing equipment. It is assumed the ash is uniformly distributed throughout the cloud leading to a flight to continue in airspace that is contaminated but not considered a risk. The issue of concern is that there could be areas of higher concentration of ash that could be a hazard to the aircraft that could be encountered after the aircraft enters the airspace.
JUSTIFICATION: Any assessment of the impact to airplane safety must include airplane structure, airplane systems (i.e., including electrical and mechanical systems, structural considerations, abrasion of external surface, etc.), powerplant and occupant safety. Abrasion studies for structure, ingestion studies for engines, auxiliary power units, avionics, environmental control systems (e.g., ozone

converters, air cycle machines, etc.) and human health inhalation studies to evaluate the health threat to passengers – all need to be accomplished to provide a valid airplane level safety assessment.
In response to question 7, the presence of sensors that would provide an alert to the flight crew in the event volcanic ash and volcanic cloud constituents must be shown to be accurate during all normal airplane flight operations and to provide the flight deck crew with notification at least several minutes before entering an ash cloud and it should be capable of detecting volcanic ash and volcanic cloud constituents. Reliability of the sensors must be high to avoid false warnings and unnecessary flight diversions, or inadvertent flight into unsafe levels of volcanic ash contamination.

comment *114* comment by: *James Crotty, FAA*

XII. Options identified

OPTION 1: Sand Testing (p. 12 of 18)

Question 5

Could sand testing provide any benefit to enhance the information available to operators for use within their VA SRAs?

Yes, sand testing as well as volcanic ash testing can provide some needed data to enhance volcanic ash SRAs, for a specific aircraft or engine model, although sand can provide misleading results due to its chemistry and morphological differences. Current ICAO standards and guidance encourage the collection of this kind of data for use in Operator's safety management system's SRAs. Additional research should be funded to identify the critical constituents and features of ash that identify the unique characteristics of ash that most impact turbine engine operation, as well as other aircraft systems and the impact on passenger health. With research, we would have a better understanding of whether sand is an adequate substitute for volcanic ash in aspects such as accelerated engine component erosion. Currently sand is not considered an adequate substitute for ash in turbine engine research testing.

Option 2: Research programme (p. 12 of 18)

Question 6

What activities could be considered in this context and which would merit prioritisation?

Research is needed in all aspects of volcanic eruptions and their effect on aircraft systems and turbine engines. The United States Government is currently funding research into volcanic ash effects on turbine engines. But much more research in this area is needed. Joint research between Europe and the United States would be helpful in accelerating our collective knowledge in this area. Additionally, research into the effects of ash on other aircraft systems and passengers should also be pursued. Research into more effective remote sensing systems and forecasting is also needed so that Operators know where dangerous ash clouds are located, both in terms of geographic location and altitudes. Improved remote sensing methods and forecasting should be the highest priority research.

Question 7

What characteristics would on-board equipment need to have in order to deliver significant operational benefit?

On-board sensing is not the optimum technique for identifying ash clouds. It should be used as a supplementary to enhance or verify forecasts that may be overly conservative. Using supplemental systems provides additional information to scientist to improve their modeling or identify gaps or deficiencies in the remote sensors, especially during IMC or night time operations.

Option 3: New Certification Specification in CS-E (p. 12-13 of 18)

Question 8

The introduction of a Certification Specification may drive engine manufactures to design an ash tolerant engine that detrimentally impacts emissions, fuel burn, required maintenance actions and cost. What would be an acceptable compromise to stakeholders?

The ICAO sponsored international volcanic ash task force (IVATF) team of experts did not propose or support international aviation authorities adoption of airworthiness regulations (i.e. Certification Specifications). This was at least partially due to the lack of near term expected advancements in international knowledge of forecasting ash and knowing its effects on engines. With current and near term expected advances, it is not likely that accurate remote sensing and forecasting will provide the required fidelity of ash concentration and precise location information that would be needed to utilize any certification specification required testing results for turbine engines. Additionally, it is currently unknown as to the effects of ash ingestion on engines with deteriorated performance as compared to newly manufactured engines.

Question 9

Can a certification test be adequately defined to address a globally applicable requirement?

With the many unknowns of ash constituents, its effects on engines, how the ash stratifies and coalesces in the atmosphere, it is currently not possible to adequately define a certification test that would truly advance aviation safety. Prior to considering imposing a certification test, a safety cost benefit analysis utilizing risk principals be utilized should be utilized in assessing the relative merits of rulemaking. This proposed analysis should consider the impacts on commerce, environmental impacts, and the cost of imposed design tradeoffs. A globally harmonized approach continuing to use the ICAO forum would more likely achieve continued incremental improvements in safety and flexible operations without the unintended consequences of an imposed Certification Specification.

Question 10

Have engine TC holders already foreseen the need to undertake specific engine volcanic ash testing? If so, can you give details of the test specification to be used?

The only engine volcanic ash ingestion testing of low levels of ash that the FAA is aware of is the U.S. sponsored Vehicle Integrated Propulsion Research (VIPR) testing planned for calendar year 2014. Engine manufacturers from both the U.S. and Europe, along with several U.S. government agencies are participating in this research. Details of how the test will be conducted and the expected outcomes are still evolving at this time. This research test is not expected to answer all potential questions on the effects of ash on engines. It is considered to be the first in what hopefully will be a continuing effort in understanding ash effects on engines.

Option 4: Generic module testing (p. 13 of 18)

Question 11

What benefits could generic module testing produce and would those benefits merit taking this work forward?

Turbine engine module testing would be a valuable component of a complete research program. Module testing is more cost effective then running a complete engine and it allows a greater degree of experimental control during testing. Typically module testing should be complimented with full engine testing to assure a complete systems level evaluation. It is not clear as to the benefits of requiring module testing as part of a Certification Specification at this time. It is recommend that the European WEZARD weather hazards research consortium work closely with researchers in North America to develop a comprehensive engine and module research testing program to advance our collective international knowledge of volcanic ash effects on turbine engines.

Option 5: Business case (Level of volcanic ash exposure set by the operator) (p. 13 of 18)
Question 12
Would such information offer benefits sufficient to merit taking this work forward
Any research data, whether engine test or module test, would be helpful to the aviation product manufacturers and the operators for their development of the required safety management systems and associated SRAs for hazard identification. ICAO Doc 9974 provides guidance to Operators for volcanic ash SRA development. Doc 9974 clearly defines the Operator as the responsible party for safety of flight. Therefore, it is in their best interest to collect as much information as possible on the effects of volcanic ash on aircraft and aircraft systems. Specific module susceptibility information would not in itself provide sufficient benefits to merit development of Certification Specifications on ash ingestion testing.

comment *14* comment by: *EUROCOPTER*

Eurocopter's answer to Question 13:
Option 2 (quicker effect in time than Options 3, 4, 5; advantage is to deal with in-service fleet) continued by Option 5 (for future engines).

comment *15* comment by: *EUROCOPTER*

Eurocopter's answer to Question 14:
Definition and harmonization of the VA threat.

comment *16* comment by: *EUROCOPTER*

Eurocopter's answer to Question 15:
The definition and harmonization of the VA threat is still needed.
Then the engine manufacturers could run their own engine susceptibility tests on a voluntary basis but pushed by the competition.

comment *17* comment by: *EUROCOPTER*

Eurocopter's answer to Question 16:
Question is specific to engine manufacturers.

comment *24* comment by: *DGAC France*

Question 13:
The most appropriate option is the definition of a research program (option 2). It is a necessary step towards improvement of our knowledge about turbine engines' characteristics. Without such efforts, any certification process would be inefficient.

Question 14:
Before commenting on a possible use of defining engine ingestion limits, it is necessary to improve the aeronautical industry's knowledge about turbine engines' resilience in areas contaminated by volcanic ash. This is why research programs should be a priority. It seems also convenient that any initiative related to establishing such engine ingestion limits should be preceded by a detailed regulatory impact assessment, which should be enough to motivate or not the establishment of a rule for that matter.

Question 15:
To answer this question it is necessary to improve the aeronautical industry's knowledge about turbine engines' robustness in areas contaminated by volcanic ash. This is why research programs should be a priority.

Question 16:
No.

comment *37* comment by: *UK CAA*

Page No: 18 of 18
Paragraph No: **Question 13**: What option(s) do you consider to be most appropriate and why? Add others if none of the above.
Comment: Option 2: Research Programme would be necessary/useful to obtain more information regarding turbine engine ash ingestion at low concentration levels before a certification specification can be clearly or realistically defined. This would also assist with establishing the resilience of existing types/models in service and in the provision of adequate continuing airworthiness tasks.
Research would also be useful in the area of aircraft on-board volcanic ash detection systems.
Option 3: A new CS-E VA ingestion requirement would ultimately require the other certification specifications (such as CS 23, 25, 27, 29, P and APU) to declare safe operations in ash criteria. A new CS-E declaration requirement would be necessary to ensure that newly certificated products meet or establish acceptable operations in low VA concentrations.
Justification: Option 2 is necessary because insufficient data currently exists in the areas of operations in low volcanic ash, and because on-board ash detection is a relatively new development which would benefit further verification and testing. By adopting a CS declaration in Option 3, it would enhance operator SRAs for safe operations in dispersed ash environments.

comment *38* comment by: *UK CAA*

Page No: 18 of 18
Paragraph No: **Question 14**: What is needed to move towards establishing engine ingestion limits?
Comment: Analysis of any tests carried out (whether these are generic or type-specific) on VA ingestion to establish feasible ash concentration target levels, and the level of the claimed side effects (such as perceived specific fuel consumption (sfc) and emissions increases, surge margin degradation etc.).
Justification: Barriers to establishing engine ingestion limits are largely due to a perceived lack of knowledge or data available.

comment *39* comment by: *UK CAA*

Page No: 18 of 18
Paragraph No: **Question 15**: In the absence of a Certification Specification for ash ingestion capability, how will volcanic ash tolerance be ensured for future engines?
Comment: UK CAA believes that ultimately a certification specification will be required to ensure ash tolerance for future engines when undergoing the certification process.
Justification: Certification specifications are the ideal means of establishing

acceptable operations in volcanic ash criteria for future types, in much the same way as other environmental hazards (rain, hail, ice and birds etc.) are addressed.

comment *40* comment by: *UK CAA*

Page No: 18 of 18
Paragraph No: **Question 16**: Can you specify expected costs and other impacts for the various options?
Comment: This question is considered to be addressed to TC Holders.
Justification: Question not applicable to NAAs.

comment *54* comment by: *Boeing*

QUESTION 13:
Boeing does not consider that there is any rationale from a safety perspective to depart from the current ICAO approach. For the reasons previously discussed, our position is that if EASA wishes to take further action on the issue of volcanic ash, then the most useful and effective next step is to formulate and execute a research program to gain a fundamental knowledge basis for EASA and the OEMs' policy, strategy, and decisions. Additionally, implementing the recommendations from IVATF, such as the VAAC best practices, and supporting the continuing work coordinated by ICAO's International Airways Volcanic Watch Operations Group (IAVWOPSG) will continue to improve the safety and efficiency of aviation during a volcanic ash event.

comment *55* comment by: *Boeing*

QUESTION 14:
Fundamentally, there needs to be a compelling safety case to move forward with establishing engine ingestion limits. Moving forward with engine ingestion limits would be detrimental to overall aviation safety because it would divert limited valuable aviation resources away from more important safety initiatives to focus on an economic issue for which the broader global aviation community has already identified, via IVATF, more effective, timely solutions. EASA and industry should continue to support the ongoing initiatives by the IAVWOPS to improve monitoring and alerting of volcanic eruptions and the forecasting of subsequent ash clouds, as well as the management of airspace and safe efficient flight operations in those conditions.

comment *56* comment by: *Boeing*

QUESTION 15:
Volcanic ash tolerance will be "ensured" as follows:
(1) Engine manufacturers will continue to design engines that are tolerant to environmental factors, such as sand and volcanic ash, as required by existing design requirements within CS-E, and, for economic reasons, to supply engines to operators who operate in such harsh environments.
(2) CS-E 540(b) is a current design requirement that addresses ingestion or strike by foreign matter that is likely to affect more than one engine. Compliance with this regulation addresses matters such as sand, dust, or volcanic ash in terms of erosion, as well as the potential for blockage of cooling air passages. Additionally, compliance with CS-E 580(a) requires the design to preclude ingress of sand and dust in unacceptable quantities or of unacceptable size into the secondary air

system.
(3) Erosion effects of volcanic ash will be covered by continuing work by engine manufacturers to address the long term effects of sand/dirt/dust erosion. Engine manufacturers will also continue to provide operators guidance to avoid flight into volcanic ash.

comment *57* comment by: *Boeing*

QUESTION 16:
To suggest ***Option 0: Do nothing*** as an option is to ignore the work accomplished by IVATF and its recommendations for future activities being adopted by IAVWOPSG. There were some 35 accomplishments from IVATF and 24 recommendations for future work to continue to enhance the safety and efficiency of aviation during volcanic ash events. EASA and industry need to continue to support the ongoing initiatives by the IAVWOPS.
Option 1: Sand testing does not reduce the cost of conducting an engine ingestion test, other than potentially reducing the cost of obtaining the ingestion material. The results of the testing would not be representative of an ash encounter and, therefore, would be of limited operational or safety value.
Option 2: Research programmes, as discussed in our response to several of the other questions, would be the most effective, appropriate path forward. Research programmes should take a broad overall view of the volcanic ash issue and not be limited to engine testing. If the research can be conducted, like VIPR3, in conjunction with other testing, the research can be relatively cost effective and address multiple objectives, e.g., engine heath monitoring and volcanic ash ingestion. The research can also be conducted with many partners so that the cost to each individual partner is reduced.
Option 3: Creating a new engine ingestion CS without first understanding the physics of the issue or having an acceptable means of compliance identified will result in substantial certification costs without a commensurate safety benefit. If a dedicated engine test is required for each new or changed engine, it will mean an additional engine added to each engine certification program, significantly increasing the hardware cost of each program. It is likely that each engine manufacturer will have to design and build facilities and equipment to direct the ash into the engine, which can add significantly to the cost of engine certification.
Additionally, a CS could drive engines to be less fuel efficient, creating more emissions, and be more expensive to operate and maintain. If a CS causes engines to be one-percent less efficient, it would create approximately 22 million more tons of CO_2 every year for flights to and from Europe (based on Emissions Trading Scheme data from the European Commission). These emissions would be created every day, regardless of whether there was a volcanic ash event, and would not eliminate the need for flight crew to exit a discernible ash encounter. There would be even more CO_2 generated globally, as the implementation would not be regional, but across the entire fleet.
With regards to VAAC products, these are defined by ICAO's Annex 3 *Meteorological Service for International Air Navigation* and the World Meteorological Organization's Technical Regulation C.3.1 to ensure standardization of information and format globally for all aviation users. IVATF facilitated VAAC "best practices" workshops that created more consistent protocols for development and presentation of VAAC products. These "best practices" protocols provide the best assessment of where ash cloud is and forecast where it is expected to go. CS specification would not appreciably change the protocol for how VAACs create their products, nor would it increase the usefulness of any on-board "ash detectors." Flight crews would still avoid operation in an ash cloud, just like they would avoid operation in severe weather

or turbulence. It is likely that each engine manufacturer will have to design and build facilities and equipment to direct the ash into the engine, which can add significantly to the cost of engine certification.
Option 4: Generic module testing may be a more reasonable approach, but without some initial research and the accumulated knowledge with which to make decisions, it could introduce significant unintended costs during the development of the module testing, e.g., research could establish which modules are most important with regards to volcanic ash susceptibility. While not insurmountable, how the generic data would be used for each specific engine certification would need to be understood, i.e., before any CS is issued, the acceptable means of compliance needs to be understood.
Option 5: Business case operators today are setting their own economic ash exposure standards, based on operating within the OEM's recommendations and their own experience. The OEMs have already provided operators with their accumulated experience from their broader fleet. Each operator has to consider many factors when they make their decision to operate during a volcanic ash event:
- first and foremost, flight safety,
- the economic impact of not flying or flying in a region with low, but non-visible or discernible ash, and
- the accuracy and timeliness of volcanic ash cloud information.
These decisions are the responsibility and prerogative of the operators. ICAO has created Doc 9974, "*Flight Safety and Volcanic Ash - Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination,*" to help assist operators and their regulatory authorities make these determinations. EASA's recommendation for European operators, in their Safety Information Bulletin 2010-17 -- to use the recommendations of ICAO Doc 9974 combined with the establishment of Volcanic Ash Advisory Centers best practices -- will enhance the safety and efficiency of operation throughout Europe.

comment *70* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 18 of 18
Question 13
What option(s) do you consider to be most appropriate and why? Add others if none of the above.
ICCAIA Comment/Response on Question 13:
ICCAIA does not feel that there is any rationale from a safety perspective to depart from the current ICAO approach. For the reasons previously discussed, our position is that if EASA wishes to take further action on the issue of volcanic ash, then the most useful and effective next step is to formulate and execute a research program to gain a fundamental knowledge basis for EASA and the OEMs' policy, strategy, and decisions. Additionally, implementing the recommendations from IVATF, such as the VAAC best practices, and supporting the continuing work coordinated by ICAO's International Airways Volcanic Watch Operations Group (IAVWOPSG) will continue to improve the safety and efficiency of aviation during a volcanic ash event.

comment *71* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 18 of 18
Question 14

What is needed to move towards establishing engine ingestion limits?
ICCAIA Comment/Response on Question 14:
Fundamentally, there needs to be a compelling safety case to move forward with establishing engine ingestion limits. Moving forward with engine ingestion limits would be detrimental to overall aviation safety because it would divert limited valuable aviation resources away from more important safety initiatives to focus on an economic issue for which the broader global aviation community has already identified, via IVATF, more effective, timely solutions. EASA and industry should continue to support the ongoing initiatives by the IAVWOPS to improve monitoring and alerting of volcanic eruptions and the forecasting of subsequent ash clouds, as well as the management of airspace and safe efficient flight operations in those conditions.

comment *72* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 18 of 18
Question 15
In the absence of a Certification Specification for ash ingestion capability, how will volcanic ash tolerance be ensured for future engines?
ICCAIA Comment/Response on Question 15:
Volcanic ash tolerance will be "ensured" as follows:
(1) Engine Manufaturers will continue to design engines that are tolerant to environmental factors, such as sand and volcanic ash, as required by existing design requirements within CS-E, and, for economic reasons, to supply engines to operators who operate in such harsh environments.
(2) CS-E 540(b) is a current design requirement that addresses ingestion or strike by foreign matter that is likely to affect more than one engine. Compliance with this regulation addresses matters such as sand, dust, or volcanic ash in terms of erosion, as well as the potential for blockage of cooling air passages. Additionally, compliance with CS-E 580(a) requires the design to preclude ingress of sand and dust in unacceptable quantities or of unacceptable size into the secondary air systems.
(3) Erosion effects of volcanic ash will be covered by continuing work by engine manufacturers to address the long term effects of sand/dirt/dust erosion. Engine manufacturers will also continue to provide operators guidance to avoid flight into volcanic ash.

comment *73* comment by: *ICCAIA - International Coordinating Council of Aerospace Industry Associations*

NPA Page 18 of 18
Question 16
Can you quantify expected costs and other impacts for the various options?
ICCAIA Comment/Response on Question 16:
To suggest **Option 0: Do nothing** as an option is to ignore the work accomplished by IVATF and its recommendations for future activities being adopted by IAVWOPSG. There were some 35 accomplishments from IVATF and 24 recommendations for future work to continue to enhance the safety and efficiency of aviation during volcanic ash events. EASA and industry need to continue to support the ongoing initiatives by the IAVWOPS.
Option 1: Sand testing does not reduce the cost of conducting an engine ingestion test, other than potentially reducing the cost of obtaining the ingestion material. The results of the testing would not be representative of an ash

encounter and, therefore, would be of limited operational or safety value.
Option 2: Research programmes, as discussed in our response to several of the other questions, would be the most effective, appropriate path forward. Research programmes should take a broad overall view of the volcanic ash issue and not be limited to engine testing. If the research can be conducted, like VIPR3, in conjunction with other testing, the research can be relatively cost effective and address multiple objectives, e.g., engine heath monitoring and volcanic ash ingestion. The research can also be conducted with many partners so that the cost to each individual partner is reduced.
Option 3: Creating a new engine ingestion CS without first understanding the physics of the issue or having an acceptable means of compliance identified will result in substantial certification costs without a commensurate safety benefit. If a dedicated engine test is required for each new or changed engine, it will mean an additional engine added to each engine certification program, significantly increasing the hardware cost of each program. It is likely that each engine manufacturer will have to design and build facilities and equipment to direct the ash into the engine, which can add significantly to the cost of engine certification.
Additionally, a CS could drive engines to be less fuel efficient, creating more emissions, and be more expensive to operate and maintain. If a CS causes engines to be one-percent less efficient, it would create approximately 22 million more tons of CO_2 every year for flights to and from Europe (based on Emissions Trading Scheme data from the European Commission). These emissions would be created every day, regardless of whether there was a volcanic ash event, and would not eliminate the need for flight crew to exit a discernible ash encounter. There would be even more CO_2 generated globally, as the implementation would not be regional, but across the entire fleet.
With regards to VAAC products, these are defined by ICAO's *Annex 3 Meteorological Service for International Air Navigation* and the World Meteorological Organization's Technical Regulation C.3.1 to ensure standardization of information and format globally for all aviation users. IVATF facilitated VAAC "best practices" workshops that created more consistent protocols for development and presentation of VAAC products. These "best practices" protocols provide the best assessment of where ash cloud is and forecast where it is expected to go. CS specification would not appreciably change the protocol for how VAACs create their products, nor would it increase the usefulness of any on-board "ash detectors." Flight crews would still avoid operation in an ash cloud, just like they would avoid operation in severe weather or turbulence. It is likely that each engine manufacturer will have to design and build facilities and equipment to direct the ash into the engine, which can add significantly to the cost of engine certification.
Option 4: Generic module testing may be a more reasonable approach, but without some initial research and the accumulated knowledge with which to make decisions, it could introduce significant unintended costs during the development of the module testing, e.g., research could establish which modules are most important with regards to volcanic ash susceptibility. While not insurmountable, how the generic data would be used for each specific engine certification would need to be understood, i.e., before any CS is issued, the acceptable means of compliance needs to be understood.
Option 5: Business case operators today are setting their own economic ash exposure standards, based on operating within the OEM's recommendations and their own experience. The OEMs have already provided operators with their accumulated experience from their broader fleet. Each operator has to consider many factors when they make their decision to operate during a volcanic ash event:
- first and foremost, flight safety,

- the economic impact of not flying or flying in a region with low, but non-visible or discernible ash, and
- the accuracy and timeliness of volcanic ash cloud information.

These decisions are the responsibility and prerogative of the operators. ICAO has created Doc 9974, *"Flight Safety and Volcanic Ash - Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination,"* to help assist operators and their regulatory authorities make these determinations. EASA's recommendation for European operators, in their Safety Information Bulletin 2010-17 -- to use the recommendations of ICAO Doc 9974 combined with the establishment of Volcanic Ash Advisory Centers best practices -- will enhance the safety and efficiency of operation throughout Europe.

comment *91* comment by: *Vereinigung Cockpit e.V.*

Question 13 & 14
From what is known now, there is an absence of known facts on engine VA and SO2 ingestion effects. So, option 2 (research) should be done with enough resources to enable estabilishment of certification standards (ption 3) that might support option 5 (business case) in the future.
Question 15
Unknown but if no limits are defined the engine TC holders will hold these limits to low values as done today.
Question 16
The cost can´t be specified, but the impact. If no limits are established, then at some point in time, after another volcanic eruption occurs, a very large volume of airspace will have to be closed to aviation . This will not only impact the aviation industry as revenue is not generated, but also society as a whole as recreational and business travel will be impeded severly, and the transport of high-value, urgent goods by air will stop. Therefore, establishment of ash limits is not an option but a necessity.

comment *96* comment by: *British Airways*

The detailed impact of exposure to ash concentrations, both cumulative and peak, under normal operations today is not known. The difficulty in ground testing is the inability to replicate both the concentrations, particle size and uniformity or lack of, that exists in the atmosphere during an eruption. There is significant value in ground testing to understand the impact of high levels of concentrations on the different components. In situ measurements during normal operations is as important as the ground testing. Operators continue to fly in areas of the globe covered by VAACs that comply with the IVATF-SCI group guidance and do not publish any form of ash concentration charts. The key to a greater and realistic understanding of the impact of ash on turbine engines is to co-ordinate ground testing and in situ testing in parallel. The value of doing one without the other is limited. To utilise any knowledge gained form this activity, it is important that pilots have the ability to assess the projected flightpath against the above findings. The three activities must run as a single programme with a co-ordinated outcome to have any value to operators in the future.

comment *110* comment by: *James Crotty, FAA*

COMMENT #12 of 13
Page: 14 of 18
Paragraph: XIII. Regulatory Impact Assessment

50. Purpose and intended effect
The proposed text states: *"Revised procedures developed by ICAO for the safe management of flight operations with known or forecast volcanic ash contamination only goes so far in addressing the perceived hazard to volcanic clouds and the associated social and economic factors. Guidance provided by ICAO restricts flight operations to areas forecast to be affected by volcanic ash or aerodromes known to be affected by volcanic ash. Prolonged flight into known volcanic ash is not permitted, and instructions to flight crews is to vacate affected areas as safely and expeditiously as possible as soon as they become aware of the hazard. In order to plan operations in areas forecast to be contaminated with volcanic ash, the operator is required to develop a Safety Risk Assessment (SRA) as part of their overall management system….."*
REQUESTED CHANGE: It is recommended that EASA wait to pursue this A-NPA until the necessary research on the impact to aviation safety from volcanic ash and volcanic cloud constituents has been completed. The FAA would support an international research team activity on this subject.
JUSTIFICATION: Research is needed before rulemaking is justified.

comment *111* comment by: *James Crotty, FAA*

COMMENT #13 of 13
Page: 15, 16, 17 and 18 of 18
Paragraph: 53. Impacts, Option 2: Research programme
The proposed text states:
"Pros
Improves understanding of risks.
Can be used to verify gas path component condition.
May be useful to have, even with the adherence to new certification limits.
Could pave the way for new methods and new technologies to increase capability to operate when ash is a hazard and so further reduce disruptions to operations.
Cons
· May still be reliant on enhanced continuing airworthiness monitoring.
….
Question 13: What option(s) do you consider to be most appropriate and why? Add others if none of the above."
REQUESTED CHANGE: It is recommended that EASA not pursue this A-NPA until the necessary research on the total effect of continuous flight in an atmosphere contaminated with volcanic ash and volcanic cloud constituents is completed.
JUSTIFICATION: The FAA believes that in order to accurately assess the risk to airplane safety, research must be completed on the adverse impact to airplane, mechanical and electrical systems, powerplant and occupant health from continuous flight through an atmosphere contaminated with volcanic ash and volcanic cloud constituents is completed.

comment *115* comment by: *James Crotty, FAA*

XIII. Regulatory Impact Assessment (p. 14-18 of 18)
Question 13
What option(s) do you consider to be most appropriate and why? Add others if none of the above.
The current ICAO approach has a proven safe track record. Therefore, the most appropriate options would be Option 0 (do nothing) for the short term with Option 2 (research) as the most beneficial for the long term. On the short term there is not enough information on precisely knowing where and how much ash is in the

atmosphere. Going forward with Option 2 provides the necessary research to remotely sense and forecast ash clouds in three dimensional space. It also provides the needed research to understand the design drivers for turbine engine volcanic ash susceptibility. Likely Option 2 will take a decade or more of concentrated research to achieve meaningful gains. Research should also be performed on other aircraft systems and passenger health. International research cooperation can mitigate costs and speed up the timeline of research achievement.

Question 14

What is needed to move towards establishing engine ingestion limits?

There currently is no safety case for establishing regulatory limits for ash ingestion. There is a potential economic case for an industry standard, to avert future interruption to air commerce. But that should not be regulated as a safety standard, but rather the market competition currently allows manufacturers and operators the ability to develop and show data to the regulators within their SRA in order to ultimately make more useable airspace available with some level of tolerable economic damage during volcanic ash events. This is an economic decision that does not need to be regulated.

Question 15

In the absence of a Certification Specification for ash ingestion capability, how will volcanic ash tolerance be ensured for future engines?

The term "ash tolerance" is the operative term. Historically, turbine engines have shown some level of tolerance with resulting economic damage when exposed to low levels of volcanic ash or sand. Both research testing and in-service experience has demonstrated that moderate to high concentrations of ingested ash can result in accelerated engine damage. With today's remote sensing, high levels of ash can be detected in advance of an encounter and have become increasingly less likely to occur. Continued efforts within the ICAO International Airways Volcano Watch Operations Group to improve both remote sensing and forecasting will continue to improve flight crew awareness of ash cloud locations. If Operators desire an improved tolerance to ash ingestion concentrations to assure an economic advantage over other Operators, then under current ICAO standards they could perform extensive testing on their hardware to demonstrate a higher level of ash ingestion capability. This then becomes a market driven concern.

Question 16

Can you quantify expected costs and other impacts for the various options?

Costs are unknown and difficult to predict. Option 0 has the least cost impact with an apparent acceptable level of demonstrated safety over the past few decades. Option 2 offers the most potential future flexibility going forward which will allow Operators to potentially utilize more air space as both the atmospheric contamination level is better known, as well as the effects on engines, aircraft and passengers.

Appendix 3: Attachments

ICCAIA Responses on EASA A-NPA2012-21 28-02-13.pdf
Attachment #1 to comment #78

ICCAIA AC Letter 064 Comments on EASA A-NPA 2012-21_280213.pdf
Attachment #2 to comment #78

Snecma letter YES 492-13-MH_Snecma comments on NPA 2012-21.pdf
Attachment #3 to comment #80

FAA Response- A-NPA 2012-21 Comment Response FINAL- 28 FEB 2013.pdf
Attachment #4 to comment #98

A-NPA 2012-21 VA CS-E_IACA input.pdf
Attachment #5 to comment #82