

**FAA Comments  
Comment Response Document for  
EASA A-NPA 2012-21**

<b>EASA DOCUMENT TITLE:</b>	<b><i>A-NPA 2012-21, Volcanic ash ingestion in turbine engines</i></b>	
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***See the attachment for answers to the 16 specific stakeholder questions posed in the A-NPA.***

**COMMENT #1 of 13**

<b>Affected paragraph and page number</b>	Page: GENERAL COMMENTS TO A-NPA Paragraph: n/a
<i>What is your concern and what do you want changed in this paragraph?</i>	<b>General Comments:</b> <ul style="list-style-type: none"><li>• International nature of volcanic eruptions and aviation necessitates a global approach and collaboration.</li><li>• Continued global collaboration through ICAO's IAWWOPSG can produce enhancements to airspace management and operational efficiencies that benefit all regions.</li><li>• 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.</li><li>• 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.</li><li>• 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.</li><li>• 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.</li><li>• Avoiding operations in visible/discernable ash has demonstrated flight safety as demonstrated by historical event experience.</li><li>• 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.</li><li>• 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.</li></ul>

**COMMENT #2 of 13**

<b>Affected paragraph and page number</b>	Page: 4 of 18 Paragraph: Section A. Explanatory Note, I. General 1.
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<p><b>What is your concern and what do you want changed in this paragraph?</b></p>	<p>The proposed text states: <i>“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.”</i></p> <p><b>REQUESTED CHANGE:</b> Research is needed to establish the risk to airplane, mechanical and electrical systems, powerplant and occupant health prior to any rulemaking activity.</p> <p>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.</p>
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<p><b>Why is your suggested change justified?</b></p>	<p><b>JUSTIFICATION:</b> 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.</p>
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**COMMENT #3 of 13**

<p><b>Affected paragraph and page number</b></p>	<p>Page: 6 of 18</p> <p>Paragraph: B. Possible courses of action IV. Background 15</p>
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<p><b>What is your concern and what do you want changed in this paragraph?</b></p>	<p>The proposed text states: <i>“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<sup>3</sup>’ to restrict flight operations, and that an ash concentration of 2 mg/m<sup>3</sup> could be used as indicative of visible ash for flight planning and night flying purposes.”</i></p> <p><b>REQUESTED CHANGE:</b> 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).</p>
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<p><b>Why is your suggested change justified?</b></p>	<p><b>JUSTIFICATION:</b> 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<sup>3</sup> is safe for airplane, mechanical and electrical systems, powerplant and occupant health. The use of 2mg/m<sup>3</sup> 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</p>
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	for airplane, mechanical and electrical systems, powerplant and occupant health for continuous flight.
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**COMMENT #4 of 13**

<b>Affected paragraph and page number</b>	Page: 6 of 18 Paragraph: V. Aims and scope of this A-NPA, 20
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<b>What is your concern and what do you want changed in this paragraph?</b>	<p>The proposed text states: <i>“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.”</i></p> <p><b>REQUESTED CHANGE:</b> 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.</p>
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<b>Why is your suggested change justified?</b>	<p><b>JUSTIFICATION:</b> 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<sup>3</sup> discussed within this NPA. Additionally elevated levels of SO<sub>2</sub> can be lethal to humans and should be directly addressed, before rulemaking allows tacit approval to fly in these ash and SO<sub>2</sub> clouds. We believe that the threshold level for safe inhalation of volcanic ash and SO<sub>2</sub> 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.</p>
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**COMMENT #5 of 13**

<b>Affected paragraph and page number</b>	Page: 7 of 18 Paragraph: V. Aims and scope of this A-NPA, 21
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<b>What is your concern and what do you want changed in this paragraph?</b>	<p>The proposed text states: <i>“In addition to the threat from ash, there are other identified threats from volcanic cloud constituents (e.g. CO<sub>2</sub>, SO<sub>2</sub>, H<sub>2</sub>S, H<sub>2</sub>, CO, HCL, HF, He, H<sub>2</sub>SO<sub>3</sub>, and H<sub>2</sub>SO<sub>4</sub>). 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.”</i></p>
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	<b>REQUESTED CHANGE:</b> 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.
<i>Why is your suggested change justified?</i>	<b>JUSTIFICATION:</b> 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>COMMENT #6 of 13</b>	
<i>Affected paragraph and page number</i>	Page: 10 of 18 Paragraph: X. The case for setting engine ash ingestion limits, Question 3
<i>What is your concern and what do you want changed in this paragraph?</i>	The proposed text states: <i>“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?”</i> <b>REQUESTED CHANGE:</b> 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.
<i>Why is your suggested change justified?</i>	<b>JUSTIFICATION:</b> 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.
<b>COMMENT #7 of 13</b>	
<i>Affected paragraph and page number</i>	Page: 10 of 18 Para: X. The case for setting engine ash ingestion limits, Question 4
<i>What is your concern and what do you want changed in this paragraph?</i>	The proposed text states: <i>“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?”</i> <b>REQUESTED CHANGE:</b> 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.
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> 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 #8 of 13**

<b>Affected paragraph and page number</b>	Page: 11 of 18 Paragraph: XI. Challenges associated with volcanic ash testing and in defining engine limits 40.
<b>What is your concern and what do you want changed in this paragraph?</b>	The proposed text states: <i>“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:</i> .... • <i>Research needs.”</i> <b>REQUESTED CHANGE:</b> 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.
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> 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 #9 of 13**

<b>Affected paragraph and page number</b>	Page: 11 of 18 Paragraph: XII. Options identified 44
<b>What is your concern and what do you want changed in this paragraph?</b>	The proposed text states: <i>“.... 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<sup>3</sup>, 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</i>

	<p><i>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.</i></p> <p><i>Unless engines are certified to a specific tolerance level, it would be necessary to continue with this approach.”</i></p> <p><b>REQUESTED CHANGE:</b> 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.</p>
<p><i>Why is your suggested change justified?</i></p>	<p><b>JUSTIFICATION:</b> 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.</p>
<p><b>COMMENT #10 of 13</b></p>	
<p><b>Affected paragraph and page number</b></p>	<p>Page: 12 of 18 Paragraph: XII. Options identified 45</p>
<p><i>What is your concern and what do you want changed in this paragraph?</i></p>	<p>The proposed text states: “... <i>Option 1: Sand testing</i> <i>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.</i></p> <p><i>Question 5 Could sand testing provide any benefit to enhance the information available to operators for use within their VA SRAs?</i></p> <p><b>REQUESTED CHANGE:</b> 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.</p>
<p><i>Why is your suggested change justified?</i></p>	<p><b>JUSTIFICATION:</b> 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</p>

	<p>component testing for the effect of specific properties (e.g., chemical reactivity, electrical conductivity, etc) may be required to argue the sand testing.</p>
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**COMMENT #11 of 13**

<p><b>Affected paragraph and page number</b></p>	<p>Page: 12 of 18 Paragraph: XII. Options identified 46</p>
<p><b>What is your concern and what do you want changed in this paragraph?</b></p>	<p>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.</p> <p>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.</p> <p>Question 6 What activities could be considered in this context and which would merit prioritisation?</p> <p>Question 7 What characteristics would on-board equipment need to have in order to deliver significant operational benefit?”</p> <p><b>REQUESTED CHANGE:</b> 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.</p> <p>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</p>

	<p>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.</p>
<p><b>Why is your suggested change justified?</b></p>	<p><b>JUSTIFICATION:</b> 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.</p> <p>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.</p>
<p><b>COMMENT #12 of 13</b></p>	
<p><b>Affected paragraph and page number</b></p>	<p>Page: 14 of 18 Paragraph: XIII. Regulatory Impact Assessment 50. Purpose and intended effect</p>
<p><b>What is your concern and what do you want changed in this paragraph?</b></p>	<p>The proposed text states: <i>“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.....”</i></p> <p><b>REQUESTED CHANGE:</b> 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.</p>

<p><i>Why is your suggested change justified?</i></p>	<p><b>JUSTIFICATION:</b> Research is needed before rulemaking is justified.</p>
<p><b>COMMENT #13 of 13</b></p>	
<p><b>Affected paragraph and page number</b></p>	<p>Page: 15, 16, 17 and 18 of 18 Paragraph: 53. Impacts, Option 2: Research programme</p>
<p><b>What is your concern and what do you want changed in this paragraph?</b></p>	<p><u>The proposed text states:</u>  <i>“Pros</i></p> <ul style="list-style-type: none"> <li>• <i>Improves understanding of risks.</i></li> <li>• <i>Can be used to verify gas path component condition.</i></li> <li>• <i>May be useful to have, even with the adherence to new certification limits.</i></li> <li>• <i>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.</i></li> </ul> <p><i>Cons</i></p> <ul style="list-style-type: none"> <li>• <i>May still be reliant on enhanced continuing airworthiness monitoring.</i></li> </ul> <p>....  <i>Question 13: What option(s) do you consider to be most appropriate and why? Add others if none of the above.”</i></p> <p><b>REQUESTED CHANGE:</b> 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.</p>
<p><b>Why is your suggested change justified?</b></p>	<p><b>JUSTIFICATION:</b> 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.</p>

**EASA A-NPA 2012-21, “Volcanic ash ingestion in turbine engines  
SPECIFIC STAKEHOLDER QUESTIONS TO BE ANSWERED**

***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.

***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?**

**EASA A-NPA 2012-21, “Volcanic ash ingestion in turbine engines  
SPECIFIC STAKEHOLDER QUESTIONS TO BE ANSWERED**

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.

***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?**

**EASA A-NPA 2012-21, “Volcanic ash ingestion in turbine engines  
SPECIFIC STAKEHOLDER QUESTIONS TO BE ANSWERED**

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

**EASA A-NPA 2012-21, “Volcanic ash ingestion in turbine engines  
SPECIFIC STAKEHOLDER QUESTIONS TO BE ANSWERED**

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 than 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 recommended 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

**EASA A-NPA 2012-21, “Volcanic ash ingestion in turbine engines  
SPECIFIC STAKEHOLDER QUESTIONS TO BE ANSWERED**

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.

***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

**EASA A-NPA 2012-21, “Volcanic ash ingestion in turbine engines  
SPECIFIC STAKEHOLDER QUESTIONS TO BE ANSWERED**

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.