



FOURTH MEETING

OF THE INTERNATIONAL VOLCANIC ASH TASK FORCE (IVATF/4)

(Montréal, Canada, 13 to 15 June 2012)

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Agenda Item 1: Opening of the meeting and organizational matters

1.1: Adoption of the working arrangements

1.2: Adoption of the agenda

1.3: Status of follow-up of IVATF recommendations

1. OPENING OF THE MEETING AND ORGANIZATIONAL MATTERS

1.1 Place and duration

1.1.1 The fourth meeting of the International Volcanic Ash Task Force (IVATF/4) was held at ICAO Headquarters, Montréal, Canada, from 13 to 15 June 2012.

1.1.2 The meeting was opened on 13 June 2012 at 1400 hours by Mr. Greg Brock, Chief of the Meteorology Section, Air Navigation Bureau, ICAO Headquarters, on behalf of Ms. Nancy Graham, Director of the Air Navigation Bureau. Mr. Brock extended a warm welcome to new and returning participants, and highlighted that this fourth meeting of the task force was the culmination of two years-worth of effort by the international community to respond to the disruption to air transportation following the eruption of the Eyjafjallajökull volcano in Iceland in April and May 2010. Mr. Brock emphasized that the meeting was an opportunity to close-out, to the extent possible, those remaining tasks on the work programme of the task force, as well as an opportunity to recognize and appreciate the accomplishments of the task force over the past 24 months.

1.1.3 Attendance

1.1.4 The meeting was attended by experts from 14 States and 9 international organizations. The list of participants is given in **Appendix A**.

1.2 Programme coordinator, project managers and officers of the Secretariat

1.2.1 The Programme Coordinator of the IVATF, Mr. P. Lechner, presided over the meeting throughout its duration.

1.2.2 The Project Managers of the four IVATF contributory Sub-Groups were as follows: Mr. T. Fudge (deputizing for Mr. L. Lachance) on behalf of the Air Traffic Management Sub-Group; Mr. R. van der Boom (deputizing for Mr. J. Schiller) on behalf of the Airworthiness Sub-Group; Ms. M. Guffanti (with Mr. M. Hort deputizing for Agenda Item 4 onwards) on behalf of the Science Sub-Group; and Mr. A. Tupper on behalf of the International Airways Volcano Watch Coordination Group.

1.2.3 Mr. G. Brock, Chief, Meteorology (MET) Section was the Secretary of the meeting, assisted by Mr. R. Romero, Technical Officer, MET Section and Secretary of the International Airways Volcano Watch Operations Group; Mr. C. Dalton, Chief, Air Traffic Management (ATM) Section and Mr. M. Fox, Chief, Flight Operations (OPS) Section. In addition, Messrs Coutu, Evans, Halsey, Hohm, Luccioli, Marin, Nie, Noreus and Theil of the Secretariat of the Air Navigation Bureau provided technical advice, where required, during proceedings.

1.3 Adoption of the working arrangements

1.3.1 The meeting adopted appropriate working arrangements.

1.4 **Adoption of the agenda**

1.4.1 The following agenda was adopted:

Agenda Item 1: Opening of the meeting and organizational matters

- 1.1: Adoption of the working arrangements
- 1.2: Adoption of the agenda
- 1.3: Status of follow-up of IVATF recommendations

Agenda Item 2: Report of the science sub-group (SCI SG)

- 2.1: Guidance material on ground-based detection methods and airborne sampling, and training material on satellite-based remote sensing techniques
- 2.2: Evaluation of volcano monitoring gaps worldwide
- 2.3: Additional scientific guidance material on ‘visible ash’
- 2.4: Recommendations for increased meteorological data gathering and sharing during a volcanic event
- 2.5: Other issues

Agenda Item 3: Report of the airworthiness sub-group (AIR SG)

- 3.1: Airworthiness issues relating to ‘visible ash’
- 3.2: Additional guidance material concerning the hazards posed by flight into SO₂ clouds
- 3.3: Additional guidance material concerning maintenance and operations considerations for international general aviation
- 3.4: Recommendations on emerging technologies that measure volcanic cloud characteristics of concern to aircraft airworthiness
- 3.5: Other issues

Agenda Item 4: Report of the air traffic management sub-group (ATM SG)

- 4.1: Air traffic management volcanic ash contingency planning template
- 4.2: Investigation into danger area terminology
- 4.3: Other issues

Agenda Item 5: Report of the international airways volcano watch coordination group (IAVW CG)

- 5.1: Enhancement of volcanic ash advisory centre products
- 5.2: Improved integration of collaborative decision making within the international airways volcano watch
- 5.3: Recommendations concerning volcanic ash data file format and accompanying volcanic ash advisory centre procedures
- 5.4: Recommendations concerning incorporation of uncertainty in SIGMET for volcanic ash

5.5: Recommendations concerning improvement to volcano observatory provisions

5.6: Concept of operations for the international airways volcano watch

5.7: Guidance concerning volcanic ash exercises

5.8: Recommendations concerning improvement to volcanic activity reporting form

5.9: Recommendations concerning the reduction or elimination of information overload during volcanic eruptions

5.10: Other issues

Agenda Item 6: Work programme status

Agenda Item 7: Summary of the accomplishments of the IVATF

Agenda Item 8: Any other business

Agenda Item 9: Closing of the meeting and of the IVATF

1.5 **Status of follow-up of IVATF recommendations**

1.5.1 The task force recalled that IVATF/2 (11 to 15 July 2011, Montreal) and IVATF/3 (15 to 17 February 2012, Montreal) had formulated thirty and eleven recommendations respectively, and that no recommendations had been formulated at IVATF/1 (27 to 30 July 2010, Montreal). The status of the follow-up of the IVATF/2 and IVATF/3 recommendations corresponding to the situation on 13 June 2012 is provided in **Appendix B**.

1.5.2 The task force was pleased to note that follow-up action on a majority of the recommendations stemming from IVATF/2 and IVATF/3 could be considered complete, with action on outstanding recommendations generally at a mature stage within the Secretariat and/or contributory ICAO groups.

1.5.3 In view of the foregoing, the task force noted that all recommendations stemming from the IVATF, including those developed by IVATF/4, would be progressed by ICAO as appropriate. The task force formulated the following Action Agreed accordingly:

Action Agreed 4/1 — Follow-up of the IVATF recommendations

That ICAO be invited to take appropriate action in respect of:

- a) those recommendations formulated by IVATF/2 and IVATF/3 identified at **Appendix B** to this report as *on-going* or *not started*; and
- b) those recommendations formulated by IVATF/4;

so as to ensure their necessary completion.

Agenda Item 2: Report of the science sub-group (SCI SG)

- 2.1: Guidance material on ground-based detection methods and airborne sampling, and training material on satellite-based remote sensing techniques**
- 2.2: Evaluation of volcano monitoring gaps worldwide**
- 2.3: Additional scientific guidance material on ‘visible ash’**
- 2.4: Recommendations for increased meteorological data gathering and sharing during a volcanic event**
- 2.5: Other issues**

2. REPORT OF THE SCIENCE SUB-GROUP (SCI SG)

2.1 Guidance material on ground-based detection methods and airborne sampling, and training material on satellite-based remote sensing techniques

2.1.1 The task force recalled that tasks TF-SCI01.1, TF-SCI01.2 and TF-SCI-01.3 had been developed at IVATF/1 and updated at IVATF/2, and concerned the restructuring of a table of capabilities and accuracies of ground-based detection methods, training material on satellite remote-sensing techniques, and the finalizing of a table concerning airborne sampling, respectively.

2.1.2 In the context of task TF-SCI01.1, the task force considered a report of the Science Sub-Group, developed in collaboration with the World Meteorological Organization’s (WMO)-International Union of Geodesy and Geophysics (IUGG) Volcanic Ash Scientific Advisory Group (VASAG), which summarized ground-based lidar capabilities for volcanic ash detection and related activities within the framework of the WMO Global Atmosphere Watch (GAW).

2.1.3 The task force noted, in particular, that ground-based lidar techniques could provide geometrical properties (top, bottom and thickness) for each volcanic layer, optical properties (extinction, backscatter and optical depth), aerosol typing and, in some cases, microphysical properties if advanced multi-wavelength Raman lidar were used. The report described several different ground-based lidar techniques that exist as well as highlighted the main limitations, such as the presence of rain, dense fog, and thick clouds (optical depths larger than 2-3) that do not allow monitoring of the atmosphere above the cloud base region, and the (maximum) altitude range that is dependent on prevailing meteorological conditions above the point of observation. A finalized list of different ground-based lidar techniques and related products was presented for the consideration of the task force in response to task TF-SCI01.1.

2.1.4 In addition, the task force noted that ground-based lidar observations could be much more powerful if used in coordinated networks, since such networks are fundamental to study atmospheric particles on large spatial scales and to investigate transport and modification phenomena. With this in mind, the report highlighted the European Aerosol Research Lidar NETwork (EARLINET) — (established in the year 2000 as the first coordinated lidar network for tropospheric aerosol study on a continental scale — and the WMO’s Global Atmosphere Watch Atmospheric Lidar Observation Network (GALION) — whose mission was to organize the observational capability for the four-dimensional distribution of key aerosol parameters on a global scale, based on the cooperation between existing lidar networks (Ad-NET, ALINE, CISLiNet, EARLINET, MPLNET, NDACC and CREST).

2.1.5 Acknowledging that technological and geographical gaps exist — such as the need to improve daytime observing capability, development of more operational lidar systems and accompanying networks (including those parts of the world where there is currently little or no capability), and near-real-time data delivery — and noting that the WMO’s GAW offers a unique long-term international

framework to provide the technical basis for integrated observations, analysis, and assessment of atmospheric chemical composition, the task force formulated the following recommendation accordingly:

Recommendation 4/1 —

That, in the context of ground-based lidar capabilities for volcanic ash detection in support of the International Airways Volcano Watch (IAVW), ICAO be invited to encourage the World Meteorological Organization (WMO) to continue its efforts to include volcanic ash in its programme of the Global Atmosphere Watch (GAW), recognizing that the GAW provides a strong framework for improving the use of lidar techniques and networks for the detection and characterization of volcanic ash in the atmosphere.

2.1.6 In the context of task TF-SCI01.2, the task force considered a report of the Science Sub-Group, developed in collaboration with the WMO-IUGG VASAG, which considered training material on quantitative, satellite-derived, volcanic ash and gas products. The task force noted that recent advances had been made in satellite remote sensing that detected volcanic ash and gas in the atmosphere and quantified ash-cloud properties such as cloud height, mass loading and particle size. In regions where the necessary satellite channels and data feeds were available, new quantitative products were available for use by Volcanic Ash Advisory Centres (VAACs) to help track and forecast ash-cloud hazards in support of the international airways volcano watch (IAVW).

2.1.7 The report highlighted that while progress in the creation of appropriate training material for quantitative satellite-data products had recently been made by national satellite agencies and government research groups that supported VAAC operations, including initiatives by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the United Kingdom Met Office and the United States National Oceanic and Atmospheric Administration (NOAA), it was to be kept in mind that because satellite capabilities to detect volcanic ash were not currently globally uniform, there were *significant disparities* in the availability of such products across the areas of responsibility of the VAACs. In order to encourage the continued development and refinement of suitable training material concerning quantitative, satellite-derived, volcanic ash and gas products for operational use by the VAACs, the task force formulated the following recommendation accordingly:

Recommendation 4/2 —

That, in the context of training material on quantitative, satellite-derived, volcanic ash and gas products, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited, in collaboration with the World Meteorological Organization (WMO)-International Union of Geodesy and Geophysics (IUGG) Volcanic Ash Scientific Advisory Group (VASAG), to continue to encourage the development and refinement of suitable training material supporting their operational use by the Volcanic Ash Advisory Centres (VAACs).

2.1.8 In the context of task TF-SCI01.3, the task force considered a report of the Science Sub-Group, developed in collaboration with the WMO-IUGG VASAG, which provided recommendations on the instrumentation for research aircraft undertaking measurements of volcanic ash plumes, and reported on the experiences from airborne observations taken in the ash plume of the Eyjafjallajökull eruption in April and May 2010.

2.1.9 The report highlighted the importance of performing airborne measurements in the eruption plume *as soon as possible* after the eruption in order to obtain early information on the eruption

source term and ash cloud properties. Therefore, research aircraft with suitable instrumentation and with experienced pilots and instrument operators should be available at short notice (within 1 to 2 days) and be capable of making measurements in the entire range of flight levels used by commercial air traffic. The crew on such sampling flights should plan flights based on all information available including data from satellites, ground-based observing systems, and predictions from dispersion models and carefully document their visual observations. Moreover, the report recommended suitable aircraft instrumentation for volcanic ash cloud sampling, including remote sensing instruments, in-situ particle instruments, trace gas in-situ instruments and standard probes that measure meteorological parameters such as temperature, pressure, humidity and wind.

2.1.10 Acknowledging that lidar and in-situ measurements from research aircraft in the ash cloud of Eyjafjallajökull supported the responsible authorities in their decisions concerning airspace closures (and reopening), provided important data to validate satellite observations and dispersion models, and that valuable scientific experience has been gained that could be useful for other airborne sampling efforts, the task force reviewed a table of capabilities of aircraft instrumentation for volcanic ash cloud sampling developed by the Science Sub-Group in coordination with the WMO-IUGG VASAG, and formulated the following recommendation accordingly:

Recommendation 4/3 —

That, in the context of airborne instrumented measurements of volcanic ash clouds, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to consider the inclusion of the recommendations at **Appendix C** to this report in the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691).

2.1.11 The task force further recalled that in the context of the above-mentioned tasks, in particular task TF-SCI01.1, the Science Sub-Group had intended to develop a table providing a side-by-side overview of various aspects of ground-based, airborne and satellite-based volcanic ash detection systems, aimed at non-expert users. The Science Sub-Group provided the task force with a brief update on the progress in this regard, where it was noted that valuable on-going preparatory work would be augmented by input from the WMO-IUGG VASAG, maintaining a focus on explaining how best to use and combine appropriate techniques for various operational needs and scenarios, with a view to further consideration at the IAVWOPSG/7 meeting and 6th International Workshop on Volcanic Ash (to be convened by ICAO and WMO respectively in March 2013).

2.2 **Evaluation of volcano monitoring gaps worldwide**

2.2.1 The task force recalled that task TF-SCI02.1, developed at IVATF/1 and updated at IVATF/2, concerned an evaluation of volcano monitoring gaps worldwide, with a view to the production of a list of volcanoes that threaten aviation and are currently unmonitored or inadequately monitored (by State volcano observatories) for the risks they pose. At IVATF/2, such a list was considered as a necessary starting point towards the goal of increasing the number of monitored volcanoes, thus promoting enhanced aviation situational awareness.

2.2.2 Preliminary work was underway within the Smithsonian Institution and the United States Geological Survey (USGS) to assemble a database of unmonitored volcanoes worldwide that threaten aviation, by adapting a basic methodology of the USGS's volcanic-threat assessment published in 2005. A more detailed effort, building on the first but adapted to aviation issues, was also being discussed by the World Organization of Volcano Observatories (WOVO) with the International Air Transport Association (IATA) as part of the follow-up to IAVWOPSG Conclusion 6/23.

2.2.3 The task force recalled that, at IVATF/3, the Science Sub-Group had indicated that the completion of task TF-SCI02.1 could not be guaranteed by the time of IVATF/4. While work was progressing as described, completion by IVATF/4 had not been feasible.

2.2.4 Recognizing the specific follow-up activity that was on-going as part of IAVWOPSG Conclusion 6/23 b), the task force agreed that the completion of task TF-SCI02.1 would be best accomplished through the IAVWOPSG. A report on the availability of the database would be presented, by WOVO through IUGG, to the IAVWOPSG/7 meeting for consideration. The task force agreed therefore, that there was no need for a (new) recommendation assigning this task to the IAVWOPSG, since it was already in progress.

2.3 **Additional scientific guidance material on “visible ash”**

2.3.1 The task force recalled that task TF-SCI03.1, developed at IVATF/2 and updated at IVATF/3, concerned the development of additional scientific guidance material to support the operational application of the IAVW, more specifically, the development of scientific guidance concerning the detectability and quantification of “visible ash” and the future scientific directions in volcanic ash cloud detection and forecasting. The Science Sub-Group, in collaboration with the WMO/IUGG Volcanic Ash Scientific Advisory Group, prepared several reports of direct relevance to task TF-SCI03.1, summarized as follows.

2.3.2 The first report relating to task TF-SCI03.1 detailed detection thresholds of satellite-based infrared sensors. The report considered the current status of satellite-based infrared sensor methods for determining volcanic ash cloud microphysics, taking into account that scientific interest in recent volcanic eruptions had led to the provision of new validation data from ground-based lidars, from aircraft measurements, and from satellite-based estimates of ash cloud-top heights. These new data suggested that ash mass loadings from infrared satellite sensors have a lower detection threshold of 0.2 g/m^2 and a standard error of $\pm 0.150 \text{ g/m}^2$ under the most favourable conditions. The report highlighted that for a volcanic ash cloud of 1 km mean thickness and uniform vertical distribution, the lower detection threshold for volcanic ash concentration estimation from satellites would correspond to $200 \text{ }\mu\text{g/m}^3$.

2.3.3 The report indicated a need, in some parts of the world, for quantitative volcanic ash retrievals. Additionally, requirements to validate and corroborate atmospheric transport and dispersion model forecasts implied a need to establish minimum thresholds and error bounds on satellite retrievals. Accordingly, the task force formulated the following recommendation:

Recommendation 4/4 —

That, taking into account that the current best estimate of the minimum satellite detection threshold for ash mass loading is 0.2 g/m^2 , with a standard error of $\pm 0.15 \text{ g/m}^2$ under favourable conditions using the most advanced retrieval methodologies, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to task the World Meteorological Organization (WMO)-International Union of Geodesy and Geophysics (IUGG) Volcanic Ash Scientific Advisory Group (VASAG) to:

- a) support the establishment of a validation data-set for benchmarking current and future satellite-based retrieval schemes; and

- b) encourage national and international space-based earth observation programmes to maintain and improve this level of coverage based on the current and future global coverage at infrared wavelengths.

2.3.4 The second report relating to task TF-SCI03.1 provided a preliminary overview of recent measurements and observations of ash-cloud thicknesses, including recent results obtained from lidar measurements during and following the Eyjafjallajökull eruption in Iceland in 2010. The report highlighted that volcanic-cloud *layering* was evident from lidar detection of volcanic ash clouds from the Eyjafjallajökull eruption, where volcanic ash was distributed heterogeneously (non-uniformly) in the troposphere as discrete, thin (<3km in vertical extent), inclined or sub-horizontal layers or lenses. Cloud density (mass concentrations) also varied within and among layers. Further evidence of ash layering in dispersing clouds had also been found during the eruption of Puyehue Cordon-Caulle volcano in Chile in June 2011 through analyses of space-based lidar (CALIOP) data. Dispersion models also showed layering, but tended to overestimate the vertical extent of the ash layers.

2.3.5 Recognizing the complexities involved, the report highlighted that a better understanding of the layering (vertical stratification) of volcanic ash clouds would come through systematically gathering observations obtained by diverse methods (e.g. ground-based, airborne and satellite-based detection methods) for as many eruptions as possible, and by improving atmospheric transport and dispersion models to better estimate mass-density distribution in volcanic ash clouds. Given the need for continued research and development of methods and techniques to help the VAACs better define the three-dimensional geometry of volcanic ash clouds, the task force formulated the following recommendation accordingly:

Recommendation 4/5 —

That, in the context of improving the definition of the three-dimensional geometry of volcanic ash clouds to support the Volcanic Ash Advisory Centres (VAACs), the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to task the World Meteorological Organization (WMO)-International Union of Geodesy and Geophysics (IUGG) Volcanic Ash Scientific Advisory Group (VASAG) to encourage further scientific investigations into volcanic-cloud thickness and stratification.

2.3.6 The third report relating to task TF-SCI03.1 detailed potential future directions for volcanic-cloud research. The report identified major online sources of recent research results and outlines topics for continuing research investigations of volcanic-cloud hazards. The task force appreciated that it had benefitted greatly from the work of many scientists in various government agencies and academic institutions around the world, who had adjusted their research programs to focus on topics of volcanic-plume characterization and ash-cloud detection and forecasting following the eruption of Eyjafjallajökull — in ways that often innovatively integrated elements of volcanology, meteorology, atmospheric physics and chemistry.

2.3.7 The report highlighted that, in the future, scientific research in support of reducing risks from volcanic-cloud hazards should aim for tangible improvements in the detection and measurement of volcanic plumes and ash clouds during eruptions and in the accuracy of model forecasts of cloud transport and dispersion. It was considered that research topics (both new and on-going) pertinent to these goals should include characterizing volcanic plumes at/near the source and understanding the evolution of volcanic ash and gas clouds in time and space. Moreover, there was a need for further analysis of hazard impacts, including additional studies of aircraft encounters with volcanic ash in order to correlate encounter conditions to volcanic-cloud properties, and engineering investigations of the effects of

ingestion of volcanic ash and gas on engines. The task force acknowledged that advances in such topics would require continued improvement of observational capabilities globally, including volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and airborne sampling, together with improved methods for sharing and combining data across sensors and specialities. In this regard, the World Meteorological Organization (WMO) acknowledged the excellent work being undertaken by the Volcanic Ash Scientific Advisory Group (VASAG) experts.

2.3.8 In view of the foregoing, the task force formulated the following recommendation accordingly:

Recommendation 4/6 —

That, in the context of future volcanic-cloud research, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to task the World Meteorological Organization (WMO)-International Union of Geodesy and Geophysics (IUGG) Volcanic Ash Scientific Advisory Group (VASAG) to continue to engage the wider scientific community in pursuit of the research topics related to volcanic-cloud hazards including, *inter alia*, characterizing of volcanic plumes at/near the source, understanding the evolution of volcanic ash and gas clouds in time and space, analysis of hazard impacts, improvement of observational capabilities globally, and improvement of methods for sharing and combining data across sensors and specialties.

2.4 **Recommendations for increased meteorological data gathering and sharing during a volcanic event**

2.4.1 The task force recalled that task TF-SCI04.2, developed at IVATF/1 and updated at IVATF/3, concerned ways and means to increase meteorological data gathering during a volcanic event. The Science Sub-Group prepared several reports of direct relevance to task TF-SCI04.2, as summarized follows.

2.4.2 The first report relating to task TF-SCI04.2 outlined the provision of meteorological data to the VAACs during a volcanic event, and highlighted that in order for the volcanic ash advisories (forecasts) issued by the VAACs to be accurate and reliable, volcanological data characterizing the eruption was required together with a full set of atmospheric data including aerosol content and volcanic ash contamination. Such data would enable the VAACs to determine parameters upon which to initialise their forecasts, and also for the verification and evaluation of the forecasts. The report cited the WMO's Global Atmosphere Watch (GAW), which had been established to monitor the presence of atmospheric aerosols by means of space-based, ground-based remote and in-situ sensing by specialized aircraft. During recent eruptions, the GAW had provided such data during volcanic eruptions to the VAACs under semi-operational conditions.

2.4.3 The report highlighted the importance of "conventional" meteorological data for atmospheric parameters of wind, temperature, humidity at high vertical and horizontal resolution is recognized for the provision of volcanic ash-related forecasts and warnings, and that WMO Member States and their national meteorological services were currently providing an adequate data set for global predictions, but with gaps understood to exist in the tropics, the oceans and some land areas in the developing world. Moreover, the need for support for the on-going development of relevant passive and active sensors for remote-sensing to the operators of meteorological satellites (through the Coordination Group on Meteorological Satellites), both in the form of clearly specified requirements as well as in political and economic forms of support, was recognized. Specialized aerosol data, currently collected for the GAW on a semi-operational basis needed to be enhanced both in density, global availability and through the availability of appropriate metadata and accessibility. Quasi-operational availability during

protracted volcanic eruption events would require a dedicated funding mechanism from either national or international disaster management funds and through appropriate cost recovery from aviation. With this in mind, the task force formulated the following recommendation accordingly:

Recommendation 4/7 —

That, in the context of improving meteorological data gathering during volcanic eruptions, the International Airways Volcano Watch Operations Group (IAVWOPSG), in close cooperation with the World Meteorological Organization (WMO) and national or regional agencies operating observing platforms, be invited to promote the availability of basic meteorological data, as well as data collection and exchange for aerosol data (and their respective contingencies), in accordance with the needs of the International Airways Volcano Watch (IAVW).

Note.— This effort should include a review of the ICAO and WMO guidance on cost recovery for aeronautical meteorological service provision with a view to ensuring any new services are contemplated.

2.4.4 The second report relating to task TF-SCI04.2, prepared in coordination with the IAVW Coordination Group due to the relationship between task TF-SCI04.2 (meteorological data gathering during a volcanic event) and task TF-VAA07 (improvements to volcano observatory provisions) summarized volcanic risk, monitoring capability and communication. The report highlighted that efforts had begun within the global volcanological community to assess volcanic monitoring capabilities and risk levels, and that strengthened communication between State volcano observatories and the aviation community was necessary to realize the benefits of improved volcano monitoring.

2.4.5 The report proposed that the assessment of volcanic monitoring capability and risk levels, and the implementation of revised IAVW arrangements including systems and channels of communication, be formally referred (by ICAO) to States, with the WMO-IUGG VASAG (through the IAVWOPSG) tasked to provide scientific advice and the VAAC Provider States tasked to facilitate progress with concerned States within their areas of responsibility. In view of the foregoing, the task force formulated the following recommendations accordingly:

Recommendation 4/8 —

That, in the ICAO communication to States and International Organizations following IVATF/4 on the accomplishments of the IVATF, attention is drawn to:

- a) the draft Amendment 76 to Annex 3 — *Meteorological Service for International Air Navigation* pertaining to improvements to volcano observatory arrangements;
- b) improved guidance in the *Handbook on the International Airways Volcano Watch — Operational Procedures and Contact List* (Doc 9766), the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691), and other new or improved guidance such as the manual on *Flight Safety and Volcanic Ash — Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination* (Doc 9974); and
- c) respective responsibilities in the context of a) and b) above.

Recommendation 4/9 —

That the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to:

- a) task the World Meteorological Organization (WMO)-International Union of Geophysics and Geodesy (IUGG) Volcanic Ash Scientific Advisory Group (VASAG) to interact with groups undertaking assessment of global volcanic risks and monitoring capabilities, by providing advice on appropriate methods for assessing aviation hazards and risks; and
- b) task the Volcanic Ash Advisory Centre (VAAC) Provider States, and the World Organization of Volcano Observatories (WOVO) through the IUGG, to take the lead in efforts to:
 - 1) improve communication channels between VAACs and States with active volcanoes; and
 - 2) review and improve related guidance within the *Handbook on the International Airways Volcano Watch — Operational Procedures and Contact List* (Doc 9766) accordingly.

2.5 **Other issues**

2.5.1 No other scientific aspects were raised under this agenda item by the task force.

Agenda Item 3: Report of the airworthiness sub-group (AIR SG)

3.1: Airworthiness issues relating to ‘visible ash’

3.2: Additional guidance material concerning the hazards posed by flight into SO₂ clouds

3.3: Additional guidance material concerning maintenance and operations considerations for international general aviation

3.4: Recommendations on emerging technologies that measure volcanic cloud characteristics of concern to aircraft airworthiness

3.5: Other issues

3. REPORT OF THE AIRWORTHINESS SUB-GROUP (AIR SG)

3.1 Airworthiness issues relating to “visible ash”

3.1.1 The task force recalled that task TF-AIR01, developed at IVATF/1 and updated at IVATF/2 and IVATF/3, concerned the development of a volcanic ash operational definition that could be used as a threshold value for the concept of “visible ash”. The task force also recalled that during a meeting of the Volcanic Ash Challenge Team (September 2011, Montreal), original equipment manufacturers (OEM) had agreed to “*work with airlines to develop criteria for night/IMC operations to avoid volcanic ash*”.

3.1.2 The task force agreed to consider a report of the Airworthiness Sub-Group regarding task TF-AIR01, despite its late submission. A presentation made by the Airworthiness Sub-Group further progressed the material as did the discussion that ensued.

3.1.3 The task force recalled that the terms *visible ash* and *discernible ash* had been used interchangeably in the past, and that this had led to confusion and misunderstandings — since both were qualitative terms used to represent a set of conditions that were difficult to quantify. The report on task TF-AIR01 outlined a proposal for an operational definition for these terms and described their use (until such time as an improved *quantitative* approach was developed and globally adopted to address the volcanic ash hazard). No final definition of visible and discernible ash was agreed by the task force at this time.

3.1.4 Noting 3.1.2 and 3.1.3 above, the task force agreed to take the following initial definitions forward to the IAVWOPSG:

- a) *Visible ash* — volcanic ash that can be observed by the human eye; and
- b) *Discernible ash* — volcanic ash that can be detected by defined impacts on the aircraft or defined in-situ and/or using remote-sensing techniques.

3.1.5 The task force noted that discernible ash also included crew-sensed volcanic ash indications, as outlined in the ICAO manual on *Flight Safety and Volcanic Ash – Risk management of flight operations with known or forecast volcanic ash contamination* (Doc 9974) paragraph 2.1. It was also noted that, depending on weather conditions and many other factors, *visible ash* may be observed in airspace described as containing *discernible ash*. The visible ash and discernible ash initial definitions presented above were proposed to be utilized for night and instrumented meteorological conditions (IMC) operations to avoid hazardous volcanic ash. The intent, as described by task TF-AIR01, would be to use the visible ash criteria as a *tactical means* to avoid volcanic ash in visual meteorological conditions (VMC), while discernible ash would be used as both a *planning and tactical means* to avoid volcanic ash.

3.1.6 The task force noted that the concept of avoiding visible ash was relatively straightforward in VMC, where volcanic ash was not obscured by meteorological clouds. The avoidance of visible ash however becomes more of a challenge in IMC or at night, since volcanic ash will generally not be visible to the crew but still present and potentially hazardous to continued safe flight.

3.1.7 The task force was informed that the approach for safe flight operations continued to be to *avoid* volcanic ash that was discernible. Consequently, in order to maintain safe flight operations with forecast volcanic ash in the atmosphere, the flight should be planned to avoid volcanic ash as defined by SIGMET information for volcanic ash or related information from other validated sources. The task force was informed that this was the same method for flight planning, in all weather conditions, day and night; however, in periods of reduced visibility, continued flight safety was increasingly dependent on the quality of a volcanic ash forecast.

3.1.8 In view of the foregoing, the task force formulated the following recommendation accordingly:

Recommendation 4/10 —

That the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to consider the concepts of *visible ash* and *discernible ash*, and, if appropriate, then develop definitions for robust operational use for volcanic ash forecasting and flight-planning purposes

3.2 Additional guidance material concerning the hazards posed by flight into SO₂ clouds

3.2.1 The task force recalled that task TF-AIR05, developed at IVATF/1 and updated at IVATF/2, concerned the development of additional guidance material related to the hazard of sulphur dioxide (SO₂) to aircraft occupants. More specifically, task TF-AIR05 was to determine, in coordination with the Science Sub-Group, how best to relocate and revise associated guidance contained in the *Handbook on the International Airways Volcano Watch — Operational Procedures and Contact List* (Doc 9766). The task force recalled that the Airworthiness Sub-Group had assumed principle responsibility for such SO₂-related matters within the IVATF, following the completion of task TF-SCI06 by the Science Sub-Group at IVATF/2.

3.2.2 As follow-up to task TF-AIR05, the Airworthiness Sub-Group had prepared a brief report that highlighted the progress made and areas of potential future work. The report referred to a recent request from the United Kingdom's Representative on the Council of ICAO to identify whether significant risk to the health of aircraft occupants exists through exposure to SO₂ in flight; what would be required to determine related thresholds for safe aircraft operations; and how would actual and forecast information on affected airspace be produced and promulgated. The task force was pleased to note information provided by SAE International during the meeting which outlined that their Aircraft Environmental Systems Committee had expertise in cabin air quality that may be of relevance for future work in this area.

3.2.3 The task force acknowledged that, with the exception of guidance to pilots on the detection of sulphurous gases on the flight deck (Doc 9766, paragraph 4.7) and the requirement for the reporting by a pilot of SO₂ detected on the flight deck using the volcanic activity report (VAR) form (PAN-ATM, Doc 4444, Appendix 1), there was currently no explicit requirement for the forecasting of SO₂ in support of international air navigation. Nevertheless, given the multidisciplinary nature of the concerns and taking into account a need to consider other hazardous gases, the task force considered that the International Airways Volcano Watch Operations Group (IAVWOPSG) should progress such matters

through its standing deliverable IAVWOPSG-04. The task force formulated the following recommendation accordingly:

Recommendation 4/11 —

That, in the context of the hazards posed by sulphur dioxide (SO₂) and other hazardous gases in the atmosphere, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited, as part of deliverable IAVWOPSG-04, to progress work on identifying and quantifying any associated health risks to aircraft occupants in coordination with the World Meteorological Organization (WMO)-International Union of Geophysics and Geodesy (IUGG) Volcanic Ash Scientific Advisory Group (VASAG), with a view to enhancing the guidance contained in the *Handbook on the International Airways Volcano Watch — Operational Procedures and Contact List* (Doc 9766).

Note. — The IVATF undertook activities relating to the hazards posed by SO₂ in the atmosphere under tasks TF-SCI06 and TF-AIR05.

3.3 Additional guidance material concerning maintenance and operations considerations for international general aviation

3.3.1 The task force recalled that task TF-AIR06, developed at IVATF/1 and updated at IVATF/2, concerned the development of maintenance and operations considerations for international general aviation, more specifically, an inventory of the international general aviation segment that required additional guidance material. The task force recalled that amendments to the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691) were developed at IVATF/2 by the Airworthiness Sub-Group concerning advice for maintenance inspections when operating in airspace contaminated by volcanic ash, and standards that had resulted in safe operations during volcanic eruptions. The task force was pleased to note that this additional guidance was about to be published by ICAO under Amendment No. 3 to Doc 9691.

3.3.2 As follow-up to task TF-AIR06, the Airworthiness Sub-Group had prepared a report that covered the *technical* aspects of maintenance considerations for international general aviation, as well as the *operational* aspects.

3.3.3 In respect of the *technical* aspects of maintenance considerations for international general aviation, the task force noted that in 2010 and 2011 the majority of engine and aircraft Type Certificate (TC) Holders had issued, re-issued and improved their instructions for maintenance and inspection with regard to operations of their aircraft and engines (including rotorcraft and international general aviation) in airspace with a low contamination of volcanic ash. The Airworthiness Sub-Group had conducted a review of the proposed amendment to Doc 9691 (outlined at paragraph 3.3.1 above) and concluded that the technical aspects of maintenance and inspection of aircraft and helicopters designed for international general aviation had been sufficiently addressed by the amendment.

3.3.4 In respect of the *operational* aspects of maintenance considerations for international general aviation, the Airworthiness Sub-Group had considered whether international general aviation could benefit from using a safety risk approach (SRA) methodology, such as was recommended for the commercial aviation sector. In this regard, the Airworthiness Sub-Group had reviewed the different types of international general aviation, and concluded that the recreational part of the sector would *not* benefit from an ICAO provision to apply the SRA methodology, since the sector does not typically suffer economically from volcanic eruptions in the same way as the commercial aviation sector, and that SRA

would not result in any appreciable benefit. In addition, the expertise to conduct a meaningful SRA was limited in the recreational part of the sector.

3.3.5 When further analysing which *types* of international general aviation operations would or could benefit from an SRA approach, the Airworthiness Sub-Group had selected the category of operators that are listed in the provisions of Annex 6 — *Operation of Aircraft*, Part II — *International General Aviation — Aeroplanes* and Part III — *International Operations — Helicopters*, since these operators were required to implement safety management systems (SMS) in their organization. The Airworthiness Sub-Group concluded that the threat of volcanic ash was, already, an intrinsic part of the SMS required for international general aviation, and therefore it should/would be addressed as a hazard in the SMS approach. For operations that *did not* require an SMS, such as certain search and rescue or medical emergency or evacuation operations, the Airworthiness Sub-Group concluded that it should be recommended that States consider allowing such operations in emergency conditions in airspace contaminated with volcanic ash, given the specific nature of the life-saving operations and taking into account that a simplified SRA may be requested for such operations by the State responsible for oversight. The Secretariat clarified that the current structure of Annex 6, as it pertains to general aviation operations, does not differentiate between recreational and non-recreational operations. The Secretariat provided further clarifications concerning the requirements for an SMS as it pertains to international general aviation operations as they are for aeroplanes and helicopters.

3.3.6 The Airworthiness Sub-Group had developed supplementary text for potential future inclusion in Doc 9691 that addressed international general aviation operations. The task force reviewed the proposal (taking into account the imminent publication of Amendment No. 3 to Doc 9691), and formulated the following recommendation accordingly:

Recommendation 4/12 —

That:

- a) the Operations Panel (OPSP) be invited to finalize the proposed additional guidance material on general aviation operations and volcanic ash, as given at **Appendix D** to this report; and
- b) upon completion of the review by the OPSP, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to consider the inclusion of the resultant material in the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691).

3.4 **Recommendations on emerging technologies that measure volcanic cloud characteristics of concern to aircraft airworthiness**

3.4.1 The task force recalled that task TF-AIR07, developed at IVATF/1 and updated at IVATF/2, related to recommendations on emerging technologies that measure volcanic ash cloud characteristics of concern to aircraft airworthiness. As follow-up to task TF-AIR07, the Airworthiness Sub-Group had prepared a report that highlighted that there were currently no design or maintenance certification standards for willingly entering an obscure cloud of volcanic debris or for operating on runways covered by debris. Since experience had shown that encounters with volcanic ash have caused extensive damage, surviving the worst encounter possible could not be assured. Additionally, technologies to compare contamination in the flight path with a reference or to record the characteristics of encounters were not available at present. Moreover, emerging technologies to record multiple encounters and to correlate with wear and damage accumulation (on-ground maintenance) were not

mature at this time, and emerging technologies to warn the flight crew of volcanic cloud and guidance to avoid the thicker part (in-flight operation) were not mature. The task force noted that when sufficient operational experience had been gained from a variety of flights, minimum operational performance specifications should be developed.

3.4.2 The report further summarized that:

- a) A safe level of contaminant could not be determined by design standards at this time;
- b) There was insufficient correlation between measured in-flight encounters characteristics and accumulated positive or negative service experience; and that a design or maintenance certification standard for airborne volcanic debris was impractical at this time;
- c) Technologies to measure, record, monitor or warn flight crew of the degree of volcanic debris contamination or damage caused by volcanic cloud were not mature or commercially available; and
- d) In-service experience of emerging technology was required to develop a minimum operational performance specification; and that experience from affected airlines (i.e. those with frequent scheduled flights in areas where volcanoes may not be observed) would provide useful experience.

3.4.3 While considering the report, the task force recalled that considerable progress on identifying suitable on-board volcanic ash detection instruments had been made by the Science Sub-Group as part of IVATF task TF-SCI01.3 (Agenda Item 2.1 refers). Noting that it was to be expected that the guidance in this regard was expected to be included in the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691) at an appropriate future stage, the task force concurred that such guidance should be taken into account as on-board operational capabilities evolve. In this regard, SAE International volunteered the work of their Integrated Vehicle Health Management Committee for maintenance of aircraft and engines.

3.4.4 In view of the foregoing, the task force formulated the following recommendations accordingly:

Recommendation 4/13 —

That an appropriate technical organization be invited to develop a Minimum Operational Performance Specification to sense and display volcanic ash cloud characteristics of concern to aircraft airworthiness to flight crew, with a view to providing tactical guidance to avoid dangerous exposure to volcanic clouds.

Note.— The results of research aircraft measurements of volcanic ash, as well as remote-sensing and forecasts, should be used as a means to correlate and validate any future operational on-board volcanic ash detection technologies.

Recommendation 4/14 —

That SAE International be invited to develop standards for aircraft health monitoring technologies and analytical processes that record the accumulative effects of volcanic ash encounters, with a view to maintaining continued airworthiness.

Note.— The real-time monitoring of effects on aircraft and engines can supplement flight crew awareness of a volcanic ash encounter.

3.5 Other issues

3.5.1 The United States briefly informed the group of a government initiative, in partnership with universities and industry representatives, to conduct an aircraft turbine engine test programme where the engine would ingest volcanic ash. The task force strongly welcomed news that engine ash ingestion testing under this programme was expected to begin in 2014, with a test summary and conclusions expected in early 2015.

3.5.2 No other airworthiness aspects were raised by the task force under this agenda item.

Agenda Item 4: Report of the air traffic management sub-group (ATM SG)
4.1: Air traffic management volcanic ash contingency planning template
4.2: Investigation into danger area terminology
4.3: Other issues

4. REPORT OF THE AIR TRAFFIC MANAGEMENT SUB-GROUP (ATM SG)

4.1 Air traffic management volcanic ash contingency planning template

4.1.1 The task force recalled that task TF-ATM01, developed at IVATF/1 and updated at IVATF/2 and IVATF/3, concerned the finalizing of an Air Traffic Management (ATM) Volcanic Ash Contingency Plan template, hereunder referred to as the “ATM VACP template”. At IVATF/3, there was a general agreement on the text of draft version 0.8 of the ATM VACP template; however, there was an expressed need for further updates with regards to meteorological issues/messages as well as for the inclusion of information on the volcano observatory notice for aviation (VONA). Accordingly, IVATF/3 had formulated Recommendation 3/9 that invited the Secretariat, *subject to completion of task TF-ATM01 by the ATM Sub-Group*, to make the finalized ATM VACP template available to all ICAO Regional Offices, thereby fostering its regional implementation.

4.1.2 Following IVATF/3, the ATM Sub-Group had strived to finalize the ATM VACP template by the 31 March 2012 deadline called for by Recommendation 3/9; however, for several reasons — including concerns related to the four phases of the contingency plan, references to contamination levels, and the continued use of danger area terminology — this deadline proved unrealistic. The ATM Sub-Group consequently worked beyond 31 March 2012 in order to finalize the ATM VACP template and provided the task force with a report on the recent progress made.

4.1.3 The report invited the task force to consider whether version 0.95 of the ATM VACP template had reached such a level of maturity that it could be given to the ICAO Planning and Implementation Groups for their use in preparing volcanic ash contingency plans for their respective regions, and to consider the future custodian of the template to support its future maintenance.

4.1.4 The task force identified editorial amendments that were necessary to version 0.95, and requested the Secretariat to include such amendments in the ATM Volcanic Ash Contingency Plan template *before* its transmission to the ICAO Planning and Implementation Regional Groups. Examples of such editorial amendments included the removal of references to modelled ash concentration charts (IVATF/3 refers), highlighting that guidance on the provision of flight information was largely governed by the provisions contained in Annex 3 — *Meteorological Service for International Air Navigation* and Annex 15 — *Aeronautical Information Services*.

4.1.5 The task force was informed by EUROCONTROL that currently, as set out in the ICAO Air Traffic Management Volcanic Ash Contingency Plan of the European and North Atlantic region (EUR Doc 019 / NAT Doc 006 Part II) and a European Aviation Safety Agency (EASA) Safety Information Bulletin, modelled volcanic ash concentration charts (as supplementary information) were still used in Europe.

4.1.6 It was recognized that the ATM VACP template would need to be revised to be consistent with the intent of associated Recommendations emanating from this meeting. This included those related to guidance on the establishment of danger areas (Agenda Item 4.2 refers).

4.1.7 Further to the ATM Sub-Group report relating to task TF-ATM01, the International Federation of Airline Pilots’ Associations (IFALPA) invited the task force to recall that task TF-ATM01,

developed at IVATF/1 in July 2010, was originally titled “ATM Contingency Planning” and included, *inter-alia*, a task to “formulate a development process to assist States and regions to establish contingency plans specific to their needs” and “develop requirements for roll-out support [...]”. IFALPA highlighted that following IVATF/1, the ATM01 task team had focussed its attention on the development of the VACP template described above without sufficient attention to these other aspects. Accordingly, IFALPA proposed that the task force give due consideration to conclude task TF-ATM01 in keeping with the original intention, including whether the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691) and the *Handbook on the International Airways Volcano Watch — Operational Procedures and Contact List* (Doc 9766) required review and revision.

4.1.8 Since the ATM VACP template was largely directed at Area Control Centres in the traditional sense of contingency planning, the current template did not effectively take into account the importance of collaborative decision-making and the need to coordinate across boundaries. In this context, the draft *Manual on Collaborative Air Traffic Flow Management* and the draft *Manual on Flight and Flow — Information for a Collaborative Environment* should be reviewed by the Secretariat to ensure that they sufficiently cover regional contingency planning scenarios. These two documents would be available to the international community in time for the ICAO Twelfth Air Navigation Conference (AN-Conf/12, 19 to 30 November 2012).

4.1.9 In view of the foregoing, the task force formulated the following recommendation accordingly:

Recommendation 4/15 —

That:

- a) following editorial amendments to be undertaken by the Secretariat, the Air Traffic Management Volcanic Ash Contingency Plan template as contained at the Attachment to IVATF/4-WP/16 should be sent to all the ICAO Planning and Implementation Regional Groups (PIRGs) for their use in preparing volcanic ash contingency plans for their respective region(s);
- b) the ICAO Air Navigation Bureau, under the lead of the Chief, Air Traffic Management Section, be the custodian of the Air Traffic Management Volcanic Ash Contingency Plan template, supported by the ICAO Planning and Implementation Regional Groups; and
- c) the ICAO Secretariat review the draft *Manual on Collaborative Air Traffic Flow Management* and the draft *Manual on Flight and Flow — Information for a Collaborative Environment* to ensure that they sufficiently cover regional contingency planning scenarios.

Note.— This recommendation replaces IVATF/3 Recommendation 3/9.

4.2 Investigation into danger area terminology

4.2.1 The task force recalled that task TF-ATM05, developed at IVATF/2 and updated at IVATF/3, concerned an investigation into danger area terminology, including its relevance in the current operating environment. As follow-up to task TF-ATM05, the ATM Sub-Group had prepared a report of the investigation undertaken, in particular danger area terminology in the context of the provision of NOTAM for volcanic ash.

4.2.2 The report highlighted that, in accordance with provisions in Annex 15 — *Aeronautical Information Services*, States were required to promulgate aeronautical information in the form of a NOTAM in respect of volcanic activity and volcanic ash. However, taking into account requirements in Annex 6 — *Operation of Aircraft* for an operator safety management system and the guidance contained in the manual on *Flight Safety and Volcanic Ash — Risk Management of Flight Operations with Known or Forecast Volcanic Ash Contamination* (Doc 9974), the ATM Sub-Group had concluded that, in general, there should be *no need* to declare a danger area or restricted area in respect of volcanic ash, *except* over and in proximity to an erupting volcano. The report cited, however, that this was without prejudice to States' rights under Article 9 of the *Convention on International Civil Aviation* (Doc 7300) to restrict or prohibit flying over the whole or any part of its territory in exceptional circumstances¹.

4.2.3 The meeting noted that this course of action did not take into account concerns related to a volcano showing significant pre-eruption activity or where the provision of timely information about foreseen volcanic activity would not be possible. The view of the task force was that in these scenarios a NOTAM without the establishment of a danger area might be promulgated, alerting flight crew of the activity. Alternatively, a restricted area above the land area or the territorial waters might be promulgated together with the associated procedures. In concluding this discussion, it was suggested that the appropriate body, most probably the AIS-AIM Study Group, should review the means of advising of pre-eruption activity.

4.2.4 A suggestion was put forward for the consideration of the task force that where volcanic contamination exists above a specific contamination cut-off value a danger area should be established by the appropriate authority and publicized by a NOTAM — including details on affected airspace users and how they are expected to handle the danger area. In the absence of specific contamination values or formal degrees of risk, this suggestion was not advanced by task force.

4.2.5 In conclusion, the task force formulated the following recommendation:

Recommendation 4/16 —

That States should not declare a danger or restricted area in respect of volcanic ash, except over and in proximity to an erupting volcano.

4.3 Other issues

4.3.1 The task force was invited to recall that IVATF/3 Recommendation 3/10 had invited the Secretariat to finalize and process the proposed draft amendment to *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444), 15.8 stemming from task TF-ATM04 concerning procedures for an air traffic control unit when a volcanic ash cloud is reported or forecast. In this regard, the task force was pleased to note the recent progress made to finalize the PANS-ATM, 15.8 proposal, and on-going steps involved to process the amendment — which included a review of the

¹ Doc 7300 Article 9 b) specifically refers.

proposed amendment to PANS-ATM by the Air Navigation Commission in the second half of 2012 in view of an intended applicability in November 2014.

4.3.2 No other air traffic management aspects were raised under this agenda item by the task force.

Agenda Item 5: Report of the international airways volcano watch coordination group (IAVW CG)

- 5.1: Enhancement of volcanic ash advisory centre products**
- 5.2: Improved integration of collaborative decision making within the international airways volcano watch**
- 5.3: Recommendations concerning volcanic ash data file format and accompanying volcanic ash advisory centre procedures**
- 5.4: Recommendations concerning incorporation of uncertainty in SIGMET for volcanic ash**
- 5.5: Recommendations concerning improvement to volcano observatory provisions**
- 5.6: Concept of operations for the international airways volcano watch**
- 5.7: Guidance concerning volcanic ash exercises**
- 5.8: Recommendations concerning improvement to volcanic activity reporting form**
- 5.9: Recommendations concerning the reduction or elimination of information overload during volcanic eruptions**
- 5.10: Other issues**

5. REPORT OF THE INTERNATIONAL AIRWAYS VOLCANO WATCH COORDINATION GROUP (IAVW CG)

5.1 Enhancement of volcanic ash advisory centre products

5.1.1 The task force recalled that task TF-VAA02, developed at IVATF/1 and updated at IVATF/2 and IVATF/3, concerned the enhancement of products issued by Volcanic Ash Advisory Centres (VAAC) within the framework of the International Airways Volcano Watch (IAVW) in accordance with Annex 3 — *Meteorological Service for International Air Navigation* provisions. The IAVW Coordination Group had prepared a comprehensive report as follow-up to task TF-VAA02 that addressed the following aspects:

- a) Availability of volcanic ash advisories in graphical format (VAG) on VAAC websites;
- b) Definition of common standards for VAACs to represent source terms;
- c) Assessment of the need/best way to communicate uncertainty in volcanic ash transport and dispersion forecasts to users;
- d) Unification of presentation of VAG;
- e) Availability of volcanic ash guidance in other formats;
- f) Frequency of issue and length of forecasts of volcanic ash advisories (VAAs);
- g) Examination of the merits of standardizing the vertical layers used in the VAA;
- h) Consideration of whether any future changes to volcanic ash guidance should be done in coordination with any changes to SIGMET information;
- i) Discussion of the merits of including so-called “threat-level” associated with each zone in the forecast ash in volcanic guidance; and

- j) Examination of the possibility of producing concentrations maps as official VAAC products².

5.1.2 The report highlighted that there was a clear desire to see improvements to current volcanic ash-related products, and that related discussions within the VAAC Best Practices Seminars (follow-up to IAVWOPSG Conclusions 6/8 and 6/9) had identified key areas where progress could and will be made, and were also intended to bring about improved consistency in volcanic ash products issued by the VAACs. Specifically, there were five areas deserving particular attention:

- a) Expression of uncertainty in forecasts;
- b) Uniformity of presentation of VAG;
- c) Frequency of issue and length of forecasts of VAAs;
- d) Standardizing the vertical layers in VAAs; and
- e) Roles of VAA and SIGMET information volcanic ash, and coordination of information between them.

5.1.3 The report noted that there was a clear desire expressed by the aviation community to receive information about uncertainty in volcanic ash forecasts as well as additional forecast times, but that there were practical constraints on how best the VAACs could provide such information. Moreover, any decisions regarding enhancements to volcanic ash advisories could not be done in isolation by the IAVW Coordination Group, and input from the rest of the task force was necessary before any work could proceed.

5.1.4 Having considered the report of the IAVW Coordination Group in this regard, the task force formulated the following recommendation accordingly:

Recommendation 4/17 —

That, in the context of enhancement of Volcanic Ash Advisory Centre (VAAC) products, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to:

- a) consider how the issues addressed by the IVATF under task TF-VAA02 can be continued, taking into account the on-going VAAC Best Practices process in seeking to address operational consistency and means to convey uncertainty and confidence in volcanic ash analyses and forecasts;
- b) address a perceived lack of uniformity of presentation of volcanic ash advisories in graphical format (VAG) by the VAACs;
- c) assess the feasibility of providing volcanic ash advisories (VAAs), including graphics (VAG), beyond the current T+18 hour requirement; and

² No further consideration of modelled volcanic ash concentration information for users in view of IVATF/3 Recommendation 3/11.

- d) in view of determining possible improvements, examine Annex 3 — *Meteorological Service for International Air Navigation* provisions regarding the number of layers that can be used to describe a volcanic ash cloud in the VAA/VAG, taking into account complex vertical stratification that may occur and the consideration that vertical segmentation should *not* be standardized at this time.

Note.— Improved production processes, format and content of all volcanic ash related messages (including volcanic ash advisories and SIGMET information for volcanic ash), are part of Deliverable-03 of the IAVWOPSG.

5.2 **Improved integration of collaborative decision making within the international airways volcano watch**

5.2.1 The task force recalled that task TF-VAA03, developed at IVATF/1 and updated at IVATF/2 and IVATF/3, concerned the improved integration of collaborative decision-making (CDM) within the IAVW. As follow-up to task TF-VAA03, the IAVW Coordination Group had prepared a report that highlighted that CDM was a cooperative effort between one or more organizations to achieve a common goal, and that part of this cooperative effort was the exchange of volcanic-ash related information for better decision-making. Information exchange tools, such as those developed by the United States³ and by Eurocontrol⁴ (highlighted in the report) were examples of means to facilitate CDM by allowing government and industry to work together when volcanic ash impacts airspace. Noting the reported success of such CDM tools, the IAVW Coordination Group proposed to promote their use in support of the IAVW (notably between the VAACs and concerned stakeholders).

5.2.2 The task force acknowledged that the IAVWOPSG/6 meeting had developed two conclusions relating to collaborative endeavours within the IAVW — Conclusion 6/12 concerning *collaborative forecasting through enhanced information sharing* and Conclusion 6/13 concerning *collaborative decision-making between the VAACs and volcano observatories* — and that any further CDM efforts should pay due respect to such work which was either on-going or recently completed. In addition, the task force further acknowledged that there will be a need to ensure not only the development of guidance but, as a necessary prerequisite, appropriate provisions in Annex 3 — *Meteorological Service for International Air Navigation*.

5.2.3 In support of task TF-VAA03, the United States invited the task force to note that CDM for future global air traffic management (ATM) would be addressed at ICAO's Twelfth Air Navigation Conference (AN-Conf/12, Montreal, 19 to 30 November 2012). To this end, the United States encouraged the task force to refer to AN-Conf/12-WP/8 which relates to *Flight and Flow Information for a Collaborative Environment — A Concept* (FF-ICE) (Doc 9965), since FF-ICE provides an excellent source for knowledge on the future concept of global ATM for performance-based navigation and the importance of CDM in ATM decision-making.

5.2.4 In view of the foregoing, in particular the need to prepare provisions (including guidelines) relating to CDM within the IAVW, and taking into account Doc 9965, the task force formulated the following recommendation accordingly:

³ Envirocast Collaborative Module – Government version (EVCM-G)

⁴ EUROCONTROL crisis Visualization Interactive Tool for ATFCM (EVITA)

Recommendation 4/18 —

That the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to consider the need to develop ICAO provisions concerning collaborative forecasting tools among the Volcanic Ash Advisory Centres (VAACs) in the production of volcanic ash advisories in support of collaborative decision-making (CDM).

Note.— The IAVWOPSG should consider Flight and Flow Information for a Collaborative Environment — A Concept (FF-ICE) (Doc 9965) where appropriate.

5.3 **Recommendations concerning volcanic ash data file format and accompanying volcanic ash advisory centre procedures**

5.3.1 The task force recalled that task TF-VAA05, developed at IVATF/1 and updated at IVATF/2 and IVATF/3, concerned the development of recommendations relating to volcanic ash data file format and procedures for use by the VAACs. As follow-up to task TF-VAA05, the IAVW Coordination Group had prepared a report detailing an investigation into the benefits of the VAACs providing comma separated variable (CSV) data files or alternatives to assist States in the issuance of consistent SIGMET information for volcanic ash, NOTAM for volcanic ash and ASHTAM. The report addressed the following aspects in this regard:

- a) Availability of CSV, or similar, product(s) on VAAC websites;
- b) Determination of the capability of various VAACs to produce such a product;
- c) Determination of the need for such a product;
- d) Determination of the best format to offer users on VAAC websites; and
- e) Identification of which volcanic ash affected regions should be characterized with CSV or similar data file formats.

5.3.2 The report highlighted that there were clear benefits if volcanic ash advisories were made available to users in a digital file format, with the best format most likely to the extensible markup language/geography markup language (XML/GML) which was becoming increasingly common as the accepted format for meteorological and geophysical data. Many, if not a majority, of VAACs already have the capability to create products in XML, but currently do not make them publically available. The CSV format, however, might also be considered as a supplemental format, but there would be a need to standardize the file format used. Lastly, a maximum number of geographical points used to define volcanic ash affected regions should also be standardized, or alternatively, a maximum data file size should be specified.

5.3.3 Having considered the IAVW Coordination Group report on task TF-VAA05, noting ongoing work within the Meteorological Aeronautical Requirements and Information Exchange Project Team (MARIE-PT) in defining XML/GML schema for meteorological information in support of future system-wide information exchange, and appreciating that additional costs would be incurred if multiple data file formats were proposed to be implemented, the task force formulated the following recommendation accordingly:

Recommendation 4/19 —

That, in the context of the data file format of volcanic ash advisories (including volcanic ash advisories in graphical format), the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to consider the development of provisions that would enable their availability in extensible markup language (XML)/geography markup language (GML).

Note 1.— In time for the IAVWOPSG/7 meeting (March 2013), the Volcanic Ash Advisory Centres (VAACs) are invited to provide an indication of their capability to provide XML/GML-formatted volcanic ash advisories.

Note 2.— Due consideration should be afforded by the IAVWOPSG to the related on-going work within the Meteorological Aeronautical Requirements and Information Exchange Project Team (MARIE-PT).

5.4 **Recommendations concerning incorporation of uncertainty in SIGMET for volcanic ash**

5.4.1 The task force recalled that task TF-VAA06, developed at IVATF/1 and updated at IVATF/2 and IVATF/3, concerned the consideration of large complex volcanic ash events, regional issuance, and incorporation of uncertainty into SIGMET for volcanic ash. As follow-up to task TF-VAA06, the IAVW Coordination Group had prepared a report that further discussed the provision of SIGMET information for large complex volcanic ash events, since regional issuance aspects were being addressed by the Meteorological Warnings Study Group (METWSG) and incorporation of uncertainty into SIGMET for volcanic ash was being addressed by the IAVWOPSG through the VAAC Best Practices process.

5.4.2 Taking into account IAVWOPSG/5 Conclusion 5/9, which had tasked an ad-hoc group to examine the issue of a complex SIGMET, and noting subsequent (related) discussions at IVATF/2 and the IAVWOPSG/6 where five possible options were considered, the task force was invited to note that the IAVWOPSG/6 did not reach consensus on which option (of the five) was most favoured, and consequently tasked a new ad-hoc group to undertake further assessment (IAVWOPSG/6 Conclusion 6/21 refers). The task force was again invited to consider the pros and cons of Option 4 — which was intended to simplify the graphical representation of a complex volcanic ash event (through the use of a fewer number of coordinate points to describe the area concerned), but meant that the coordinate set used may differ from the text-based SIGMET equivalent — and consider whether this may be a suitable interim solution. To this end, the task force formulated the following recommendation accordingly:

Recommendation 4/20 —

That, as a means to resolve issues related to SIGMET information for large complex volcanic ash events, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to further evaluate Option 4 (see Note) as an interim solution that may provide the necessary consistency within, and strategic direction for, the International Airways Volcano Watch (IAVW).

Note.— Option 4 was presented by the IVATF IAVW Coordination Group at IVATF/2 (11 to 15 July 2011) and included in Appendix 5B (Options for the depiction of SIGMET for volcanic ash in graphical format) of the IVATF/2 Report.

5.5 Recommendations concerning improvement to volcano observatory provisions

5.5.1 The task force recalled that task TF-VAA07, developed at IVATF/1 and updated at IVATF/2 and IVATF/3, concerned the improvement of volcano observatory provisions, in particular, the consideration of additional measures necessary to improve eruption prediction and notification by State volcano observatories in support of the IAVW. The task force noted that aspects in this regard had been addressed as part of a conjoint follow-up with task TF-SCI04.2, as considered under Agenda Item 2.4.

5.6 Concept of operations for the international airways volcano watch

5.6.1 The task force recalled that task TF-VAA10, developed at IVATF/2, concerned the further development of a Concept of Operations for the IAVW. The task force was pleased to note that the IAVW Coordination Group, as follow-up to task TF-VAA10, had developed a revised draft of the Concept of Operations that took into account feedback received after IVATF/2, and during and since IVATF/3. The report highlighted the progress made to date to mature the Concept of Operations, together with recommendations of where future efforts should be concentrated, including a full review of the functional requirements and supporting performance metrics that would define the level of service expected in the near term and services expected in future years.

5.6.2 The task force concurred that the Concept of Operations could provide the necessary strategic direction for the IAVW, however concerns were expressed with regards to certain terminology currently used.

5.6.3 Recognizing that the Concept of Operations for the IAVW was not sufficiently mature at this time, the task force concurred that the most appropriate group to progress its development would be the International Airways Volcano Watch Operations Group (IAVWOPSG). The task force formulated the following recommendation accordingly:

Recommendation 4/21 —

That, in the context of the development of a Concept of Operations for the International Airways Volcano Watch (IAVW), the Secretariat make the latest draft available on the International Airways Volcano Watch Operations Group (IAVWOPSG) website by 31 August 2012 and invite the IAVWOPSG to provide comment on the draft in time for the IAVWOPSG/7 Meeting to enable its further development.

Note.— The latest draft of the Concept of Operations for the IAVW was included in the Appendix to IVATF/4-WP/24.

5.7 Guidance concerning volcanic ash exercises

5.7.1 The task force recalled that task TF-VAA11, developed at IVATF/2, concerned the development of volcanic ash exercise guidance to foster and support regional volcanic ash exercises held in ICAO Regions. As a follow-up to task TF-VAA11, the IAVW Coordination Group had prepared a report that included such guidance. The guidance provided an overview of volcanic ash exercises, performance assessments, objectives and concepts, planning and reporting.

5.7.2 The task force considered the utility of incorporating the volcanic ash exercise guidance into either the *Manual on Volcanic Ash, Radioactive material and Toxic Chemical Clouds* (Doc 9691) or the *Handbook on the International Airways Volcano Watch — Operational Procedures and Contact List* (Doc 9766). In view of its operational nature, the task force recalled that Doc 9766 was updated on a near-to-real-time basis, with the latest version always available on the (publically accessible) IAVWOPSG website⁵. Given the need to conduct volcanic ash exercises with a wide range of concerned stakeholders (meteorologists, volcanologists, air traffic flow managers, airlines, etc.), the task force concurred that Doc 9766 would be the more appropriate placeholder for the new guidance. The task force formulated the following recommendation accordingly:

Recommendation 4/22 —

That the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to consider the inclusion of guidance for conducting volcanic ash exercises in ICAO Regions, as presented at **Appendix E** to this report, in the *Handbook on the International Airways Volcano Watch — Operational Procedures and Contact List* (Doc 9766).

5.8 Recommendations concerning improvement to volcanic activity reporting form

5.8.1 The task force recalled that task TF-VAA12, developed by IVATF/2 and updated at IVATF/3, concerned improvements to the volcanic activity report (VAR) form, including taxonomy and transmission, in support of the IAVW, and was related to task TF-ATM03 which was considered to be complete from an Air Traffic Management Sub-Group perspective at IVATF/3.

5.8.2 As follow-up to task TF-VAA12, the IAVW Coordination Group had prepared a report that highlighted that a comparison of various existing ICAO and non-ICAO VAR forms had been

⁵ <http://www.icao.int/safety/meteorology/iavwopsg/>

undertaken at IVATF/2, together with an analysis of the taxonomy used; however, due to resource limitations, the task force noted that the IAVW Coordination Group had been unable to conduct a comprehensive review of the material in order to determine what improvements, if any, could be made to the existing ICAO model VAR in the Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444). Nevertheless, the IAVW Coordination Group had identified several steps necessary to accomplish such an undertaking, summarized as follows:

Step 1 – Future work should be to agree on a revised ICAO model VAR for Doc 4444, including improved pilot guidelines for completion and reporting procedures, together with a review of the necessity to adapt Annex 3 provisions. This work should include a review of the different taxonomies used currently and determine the need for global harmonization; and

Step 2 – Address improvements in the distribution processes. Whether this includes a need for amendment of ICAO provisions still needs to be determined, however one core element of this work would be the creation of a central repository of VARs as part of the developing system wide information management (SWIM).

5.8.3 The IAVW Coordination Group proposed that a potential follow-on step to Step 1 might be the requirement to provide electronic means *in-flight* for the completion of the revised VARs initially via electronic flight bags (EFBs), but ultimately supported by design changes of airborne equipment. It was highlighted that such an undertaking would require coordination with the work of the AIS/AIM Study Group (AIS/AIM SG) as well as associated airworthiness issues.

5.8.4 In view of the fact that improvements to VAR forms and procedures were considered necessary to achieve an increased rate of reporting of volcanic activity and/or contamination by special air-reports, and in order to progress, in full, the follow-up to task TF-VAA12, the task force formulated the following recommendations accordingly:

Recommendation 4/23 —

That, in the context of the volcanic activity report (VAR) form, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to:

- a) develop a revised ICAO model VAR form based on the comparison and recommendations provided at **Appendix F** to this report;
- b) develop suitable provisions to enable the introduction of a revised ICAO model VAR form, including associated production and dissemination processes;
- c) continue work on establishing a global repository for VAR forms; and
- d) explore near-future interactive electronic means for the in-flight completion of the VAR form and provide an outline of a far-future integrated communications concept.

Note.— The IAVWOPSG may wish to consider forming of a small interdisciplinary ad-hoc group to progress the foregoing in advance of IAVWOPSG/7.

5.9 Recommendations concerning the reduction or elimination of information overload during volcanic eruptions

5.9.1 The task force recalled that task TF-VAA13, developed at IVATF/3, concerned ways and means to reduce or eliminate (aeronautical and meteorological) *information overload* during volcanic eruptions. As follow-up to task TF-VAA13, the IAVW Coordination Group had prepared a report that reviewed the current processes regarding the issuance of aeronautical and meteorological information in view of reducing or eliminating such concerns. In particular, the report addressed SIGMET information for volcanic ash and NOTAM for volcanic ash, their relationship with each other and with the volcanic ash advisories (VAAs) (issued by volcanic ash advisory centres).

5.9.2 In respect of SIGMET information for volcanic ash, the report highlighted overlaps with VAAs in terms of their purpose and audience, leading to issues of precedence and confusion, especially if the information provided was in conflict. Much discussion had centred on whether one or other of the messages could be eliminated; however, the report cited that unless both local and broad-scale needs could be met in a single product, it would not be practical, at this time, to internationally agree on such a major step. The IAVW Coordination Group proposed that it was necessary to prioritize the development of the collaborative environment (involving meteorological watch offices, volcanic ash advisory centres, area control centres, etc.) necessary to create unified, globally and locally applicable products. The Secretariat outlined on-going work within the Meteorological Warnings Study Group (METWSG) which was studying ways and means to improve the global implementation of SIGMET information. Given the lack of implementation of SIGMET information in some parts of the world, and the fact that today's SIGMET provision is flight-information region (FIR)-based rather than phenomenon-based, the task force was apprised that METWSG was giving due consideration to all aspects of the provision of information for hazardous weather, with a view to formulating proposals for the planned Meteorology Divisional Meeting in 2014.

5.9.3 In respect of NOTAM for volcanic ash, the report highlighted that this area had been greatly assisted by the major shift in thinking of operator's and State's responsibilities reflected in the manual on *Flight Safety and Volcanic Ash — Risk management of flight operations with known or forecast volcanic ash contamination* (Doc 9974). However, in order to further progress, the report indicated that any changes to NOTAM for volcanic ash would need to pay careful attention to the developments in other (related or similar) products such as the SIGMET information and VAA described above, and also recognize the progress of the AIS-AIM Study Group (AIS-AIM/SG) which had been developing NOTAM templates for volcanic ash events.

5.9.4 In order to reduce or eliminate the information overload concerns, and appreciating the complexities involved, the task force recognized that a critical factor for success — and in the success of the relationship between the volcanic ash advisories, SIGMET information for volcanic ash and NOTAM for volcanic ash — would be a close, collaborative and trusted decision-making process among concerned stakeholders.

5.9.5 Complementing the IAVW Coordination Group report on task TF-VAA13, the task force also considered a report prepared by IFALPA concerning Annex 15 provisions for NOTAM for volcanic ash and Annex 3 provisions for SIGMET for volcanic ash. The task force considered that the elimination of identical requirements for certain elements in NOTAM and SIGMET (for volcanic ash) could ease information overload concerns, and that a review of the respective Annex 15 provisions to eventually develop a more streamlined information flow would be desirable.

5.9.6 In view of the foregoing, the task force formulated the following recommendation accordingly:

Recommendation 4/24 —

That, in the context of ways and means to reduce or eliminate *information overload* during volcanic eruptions, and noting the complexities and complementary roles of volcanic ash advisories, SIGMET information for volcanic ash, and NOTAM for volcanic ash, the International Airways Volcano Watch Operations Group (IAVWOPSG) be invited to:

- a) consider what, if any, urgent strategies, additional to enhanced collaborative processes, may be necessary to build consistent, best-practice volcanic ash analysis, forecasting and advice across the International Airways Volcano Watch (IAVW);
- b) review, in coordination with the Meteorological Warnings Study Group (METWSG), the future need for volcanic ash advisories and SIGMET information for volcanic ash; and
- c) review, in coordination with the Aeronautical Information Services to Aeronautical Information Management Study Group (AIS-AIM/SG), existing provisions in Annex 15 — *Aeronautical Information Services* concerning NOTAM for volcanic ash, in light of a) and b) above.

5.10 **Other issues**

- 5.10.1 No other IAVW aspects were raised by the task force under this agenda item.

Agenda Item 6: Work programme status

6. WORK PROGRAMME STATUS

6.1 The task force recalled that at each of its previous three meetings (IVATF/1 held 27 to 30 July 2010, IVATF/2 held 11 to 15 July 2011 and IVATF/3 held 15 to 17 February 2012) it had developed, reviewed and updated its work programme with respect to tasks and expected deliverables of the four IVATF contributory sub-groups, namely the Science Sub-Group, the Airworthiness Sub-Group, the Air Traffic Management Sub-Group and the International Airways Volcano Watch Coordination Group.

6.2 Recognizing that the IVATF/4 meeting would serve as the conclusion of the task force's activities, there was a clear need to determine those tasks within the work programme which could be considered complete, and those which remained incomplete and would require assignment to an appropriate ICAO group or groups so as to ensure their appropriate follow-up and/or completion.

6.3 To this end, and taking into consideration the outcomes of the IVATF/4 meeting, specifically under Agenda Items 2 to 5 inclusive, the task force undertook a final review of the status of each of the tasks/deliverables within its work programme.

6.4 Having completed a review and updated its work programme accordingly, the task force was very pleased to note that all of the tasks/deliverables on its work programme could be considered complete from an IVATF perspective (**Appendix G** refers).

6.5 Acknowledging a need for continued engagement of all types of decision-makers and technical experts in the future development of the International Airways Volcano Watch (IAVW), EUROCONTROL invited the task force to give consideration to ensuring that experts from appropriate fields of expertise — e.g. ATM, MET, AIS, aircraft operations and airworthiness — address the various aspects of volcanic ash, in much the same way as has been accomplished through the work of the IVATF. In order to ensure the effectiveness of future developments, the task force concurred that it would be highly desirable to ensure greater involvement and a more prominent role of decision-makers, in particular, representatives of airspace users and competent authorities in States from the fields of airspace policy and airworthiness.

6.6 Appreciating that the majority of the outcomes of the task force would now be progressed, or were already being progressed, by the International Airways Volcano Watch Operations Group (IAVWOPSG), the task force concurred that the IAVWOPSG, in particular, should give due consideration to its future composition – to ensure necessary involvement of all concerned stakeholders – and working methodology – to ensure existing and emerging issues relating to the IAVW can continue to be handled in an efficient and effective manner. In this regard, the task force was of the view that a mechanism similar to how the IVATF had progressed its work, i.e. with sub-groups assigned to address specific tasks, may be considered by the IAVWOPSG as a suitable means to address inter-disciplinary issues. Consequently, the task force was of the opinion that the composition of the IAVWOPSG in the future should be balanced, whereby the involvement of key players from different fields of expertise and different regions would ensure that future developments would be globally supported.

6.7 In addition, the task force considered a proposal for the establishment of a high-level body, in which decision-makers could play a prominent role, could assist in the setting of global provisions, and could drive and monitor future volcanic ash developments in order to support continued safe flight operations while respecting the socio-economic impacts of any developments. Taking into account the Terms of Reference of the IAVWOPSG which addresses many of these aspects, and noting that ICAO had established a Volcanic Ash Challenge Team (VACT) in September 2011 targeted at senior-level decision-makers from concerned States and International Organizations, the task force, in agreeing with the merits of the proposal, noted that the progress of this initiative would be handled by ICAO as necessary.

Agenda Item 7: Summary of the accomplishments of the IVATF

7. SUMMARY OF THE ACCOMPLISHMENTS OF THE IVATF

7.1 The task force recalled that in response to the disruption to air transportation in the ICAO European and North Atlantic Regions and beyond caused by the April and May 2010 eruption of the Eyjafjallajökull volcano, the Secretary General of ICAO had established the multi-disciplinary IVATF on 18 May 2010 to assist the Secretariat in the development of a global safety risk management framework that would make it possible to determine the safe levels of operation in airspace contaminated by volcanic ash. The work of the task force was complementary to existing work within the International Airways Volcano Watch Operations Group (IAVWOPSG).

7.2 Based on its work programme, the task force reviewed a summary of its significant accomplishments made since its first meeting (IVATF/1) in July 2010, as the community had strived to address the issues highlighted during and since the eruption. The task force concurred that its work since IVATF/1 had demonstrated that the response to such an internationally-significant event could not have been done in isolation, and that a coordinated and collaborative international response had been, and would remain, essential. The task force had succeeded in bringing together multi-disciplinary groups with the common objective of improving the safety and efficiency of international air navigation in the face of a crisis that had far reaching impacts.

7.3 The task force acknowledged that following IVATF/4 much of the future work to enhance the International Airways Volcano Watch (IAVW) would return to IAVWOPSG, where, already, there was now engagement from airworthiness and air traffic management experts. Other standing ICAO groups would also be expected to fulfil respective obligations, supported by appropriate voluntary expertise from States and International Organizations, in order to ensure that the community would be able to improve international arrangements relating to volcanic eruptions into the future.

7.4 The task force extended its gratitude and appreciation to *all* the experts from States and International Organizations who had contributed to achieving the significant accomplishments of the IVATF, and who would, in many instances, continue to provide voluntary support to the collaborative endeavours through the standing ICAO groups.

7.5 The task force acknowledged that the challenges faced during and since the eruption of Eyjafjallajökull had been, in many instances, significant. Experts had worked diligently to address the issues highlighted by this and other significant eruptions to the extent possible, and there was now a much-improved understanding and awareness of the hazards posed by volcanic ash in the atmosphere on continued safe and efficient flight operations, across multiple disciplines.

7.6 Undoubtedly, some challenges remain, and the task force concurred that these challenges presented opportunities to further extend the community's collaborative scientific understanding and operational response to volcanic eruptions, wherever and whenever in the world they would occur.

7.7 The task force recognized that it had accomplished its principle objective: *the development of a global safety risk management framework that makes it possible to determine the safe levels of operation in airspace contaminated by volcanic ash*, and the task force was tremendously proud of this and its other significant accomplishments during the past 24 months.

7.8 The task force concurred that the summary of the accomplishments of the task force should form the basis of an executive summary of the IVATF as a whole, and used as a communication tool post-IVATF.

Agenda Item 8: Any other business

8. ANY OTHER BUSINESS

8.1 Iceland informed the task force of the availability of a comprehensive report on the 2010 eruption of the Eyjafjallajökull volcano. The Icelandic Meteorological Office (IMO), Institute for Earth Sciences (IES) of the University of Iceland, and the Department of Civil Protection and Emergency Management of the National Commissioner of the Icelandic Police (NCIP-DCPEM) had compiled the report which included information on the geophysical monitoring system in Iceland, a detailed overview on the eruption, analysis of the event with discussion and main findings and lessons learned. The task force expressed its appreciation to Iceland for the making hard-copies of the report available to the participants of the meeting. The task force also pleased to note that the report was available on the IMO website⁶.

8.2 The task force also noted with appreciation a progress report from Australia on the Volcanic Ash Advisory Centre (VAAC) Best Practices process, initiated by the International Airways Volcano Watch Operations Group (IAVWOPSG) in 2011, and partially sponsored by the International Air Transport Association (IATA). Two VAAC Best Practices Seminars had been held so far (February 2012 and June 2012) and had proven to be extremely valuable in exchanging information on the various aspects of best operational practices among the VAACs, including coordination, collaboration and consistency, improvements to volcanic ash advisories and related products (including the expression of uncertainty and the use of operational data such as from satellites). The task force was informed that the Second VAAC Best Practices Seminar, held immediately prior to IVATF/4, had articulated a best practice analysis process as being:

The expert evaluation of the best available sources of meteorological and volcanological information:

- a) qualitative and quantitative satellite data;
- b) model output;
- c) ground- and airborne-based in-situ and remotely sensed observations; and
- d) air reports;

using (where possible) collaborative approaches, to derive authoritative, high quality, evidence-based and globally-consistent volcanic ash analyses and forecasts.

8.3 The task force was informed of concerns expressed during the Second VAAC Best Practices Seminar regarding future VAAC resourcing, but was pleased to note that the next IAVWOPSG meeting (in March 2013) was expected to receive a report on the outcomes of the best practices process where such issues would be addressed further.

8.4 No other items were raised by the task force under this agenda item.

⁶ <http://en.vedur.is/about-imo/publications/2012>

Agenda Item 9: Closing of the meeting and of the IVATF

9. CLOSING OF THE MEETING AND OF THE IVATF

9.1 The Secretary General of ICAO, Mr. R. Benjamin, provided a closing address to the task force.

9.2 Recognizing the significant disruption to air transportation in Europe and beyond that had resulted from the eruption of the Eyjafjallajökull volcano in Iceland in April and May 2010, the Secretary General recalled that he had established the multi-disciplinary International Volcanic Ash Task Force (IVATF) to assist the Secretariat with a principle objective, namely, the development of a global safety risk management framework that would make it possible to determine the safe levels of operation in airspace contaminated by volcanic ash. It was highlighted that the work of the IVATF was complementary to the International Airways Volcano Watch Operations Group (IAVWOPSG).

9.3 In his address, the Secretary General highlighted the significant accomplishments of the task force since its first meeting in July 2010, across multiple disciplines. He expressed his personal satisfaction in the efficiency and effectiveness with which the task force had progressed its work, and acknowledged that the task force had, among many other significant accomplishments, fulfilled the principle objective outlined above through the development and publication of the ICAO manual on *Flight Safety and Volcanic Ash — Risk management of flight operations with known or forecast ash contamination* (Doc 9974).

9.4 Notwithstanding the significant progress that had been made, the Secretary General acknowledged that some challenging issues remained. It was emphasized that any challenges should be viewed as opportunities for the community to further extend the collaborative scientific understanding and operational response to volcanic eruptions, whenever and wherever in the world they will occur, and the Secretary General expressed his personal commitment as well as that of ICAO to support future work.

9.5 The Secretary General extended his sincerest appreciation to all of the experts from States and International Organizations who had assisted with the work of the task force, and who, in many instances, would continue to assist the international community to enhance the safety and efficiency of international civil aviation in the face of natural hazards such as volcanic eruptions through standing ICAO groups. In addition, the Secretary General acknowledged the significant contribution of the Secretariat, who had been assigned the responsibility of assisting the task force, in addition to fulfilling the regular work programme, at a time of limited resources.

9.6 Extending the sentiments of the Secretary General, the Director of the Air Navigation Bureau, Ms. N. Graham, also acknowledged the accomplishments of the task force, and paid special appreciation to all of the experts involved. In particular, Ms. Graham thanked the Programme Coordinator and the Sub-Group Project Managers of the task force for their considerable efforts during the past 24 months.

9.7 The meeting closed at 1530 hours on 15 June 2012.

APPENDIX A

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APPENDIX B

STATUS OF FOLLOW-UP ON RECOMMENDATIONS FORMULATED BY IVATF/2 AND IVATF/3

(as at 13 June 2012)

A.1 RECOMMENDATIONS OF IVATF/2 (HELD 11 TO 15 JULY 2012, MONTREAL)

Rec.	IVATF domain ⁷	Nature of recommendation ⁸	IVATF follow-up status
2/1	SCI	Perform a full assessment of different ground-based techniques	Complete
2/2	SCI	Development of guidance and training material regarding the operational use of quantitative satellite-derived volcanic ash and gas products	Complete
2/3	SCI	Recommendations concerning airborne measurements of volcanic ash, in view of inclusion in Doc 9766	Complete
2/4	SCI	Increase use by volcano observatories of the aviation colour code and VONA; and production of a list of volcanoes that threaten aviation and are unmonitored/inadequately monitored	Complete
2/5	SCI	Database of measurements and observations of ash cloud thicknesses; detection thresholds of various space-based sensors; research on cloud property automatic algorithms; validate VAAC-defined ash clouds against observations to establish guidelines/standards for “visible ash”; analysis of ash observations and model results against past aircraft encounters	Complete
2/6	SCI	To more clearly specify common best practices procedures for preparing [VAAC] advisory products	Complete
2/7	SCI	Inclusion in Doc 9691 of preliminary guidance information on volcanic materials for engine testing	Complete
2/8	SCI	Efforts to improve eruption detection and measurement capabilities, improve knowledge and use of ESP, characterize uncertainty, etc	Complete
2/9	SCI	Procedures on how to share information between WMO Member States and volcano observatories	Complete
2/10	SCI	Assess findings concerning uncertainty in ash dispersion model forecasts in the development of operational advisory and warning products	Complete
2/11	SCI	Work towards the improvements in dispersion modelling	Complete
2/12	SCI	Explore the development of near-real-time ensemble capabilities and prototype probabilistic products	Complete
2/13	AIR	Amend EUR/NAT Volcanic Ash Contingency Plan based on findings of task TF-AIR01	Not started ⁹

⁷ SCI – Science Sub-Group; AIR = Airworthiness Sub-Group; ATM = Air Traffic Management Sub-Group; and IAVW = International Airways Volcano Watch Coordination Group.

⁸ Refer to the [IVATF/2 Report](#) for the full description of the recommendations.

⁹ Subject to completion of task TF-AIR01 of the Airworthiness Sub-Group of the IVATF

Rec.	IVATF domain ⁷	Nature of recommendation ⁸	IVATF follow-up status
2/14	AIR	Finalize the proposed guidance on the <i>management of flight operations with known or forecast volcanic ash cloud contamination</i>	Complete
2/15	AIR	Finalize amendment proposals to ICAO Docs 9691, 4444 and EUR Doc 019/NAT Doc 006 Part II	On-going
2/16	AIR	Finalize and incorporate in Doc 9691 proposed additional guidance on general advice for aircraft maintenance inspection	On-going
2/17	AIR	That airport operations be considered for inclusion in the guidance for the management of flight operations with known or forecast volcanic cloud contamination	On-going
2/18	AIR	To improve aerodrome and ATM procedures by extension of written procedures	On-going
2/19	AIR	Incorporation in appropriate ICAO Doc of volcanic ash communication process for OEM expert advice	On-going
2/20	ATM	Acceptance of the first draft template ATM contingency plan for volcanic ash	Complete
2/21	ATM	Those [ICAO] groups working on advanced technologies for dissemination of information be provided with operational requirements; and develop a migration plan to these advanced technologies	On-going
2/22	ATM	Review the detailed results of the investigation into flight planning information dissemination	Complete
2/23	ATM	IATA and IFALPA, in coordination with IAVW CG, to provide detailed operations requirements for information on volcanic contaminants	Complete
2/24	ATM	Clarification [from IAVW CG] with regards to what volcanic activities need to be reported by pilots (e.g. pre-eruptive volcanic activity)	Complete
2/25	ATM	ATM SG [in coordination with IAVW CG] examine ways to improve the quantity and quality of information on volcanic activities, including AIREP	Complete
2/26	ATM	IAVW CG [in coordination with ATM SG and AIR SG] work on: development of a universal VAR (with guidance); appending of post-flight maintenance findings to VAR; means to ensure electronically available VAR	Complete
2/27	IAVW	Evaluation of option for the depiction of complex VA clouds in graphical SIGMET	Complete
2/28	IAVW	Consider proposed revision to Doc 9766 concerning VO support for decision making, and consideration of implications on other ICAO guidance	Complete
2/29	IAVW	Consider proposed amendment to Annex 3, 3.6 concerning State volcano observatory monitoring of active or potentially active volcanoes	Complete
2/30	IAVW	Consider the possibility of undertaking a SIP to ensure effective implementation of IAVW procedures.	Complete

**A.2 RECOMMENDATIONS OF IVATF/3
(HELD 15 TO 17 FEBRUARY 2012, MONTREAL)**

Rec.	IVATF domain	Nature of recommendation¹⁰	IVATF follow-up status
3/1	IAVW	VAAC assistance to the Secretariat in the undertaking of approved Special Implementation Projects targeted at States that maintain volcano observatories	Complete
3/2	SCI/IAVW	IAVWOPSG to invite WOVO through IUGG to develop further suitable guidance material to foster the increased use of the aviation colour code and the volcano observatory notice for aviation by volcano observatories	Complete
3/3	AIR	Communication to the wider stakeholder community of aspects relating to the observation and forecasting of volcanic ash concentration and “visible ash”.	On-going
3/4	AIR	Assignment, through the ANC, of Doc 9974 to the Operations Panel.	On-going
3/5	AIR	Revision of Operations Panel processes to secure equitable involvement of all stakeholders in the ongoing development of Doc 9974	On-going
3/6	AIR	Co-branders of Doc 9974 to be invited to participate in the Operations Panel to secure their ongoing involvement and agreement in the development of this guidance.	On-going
3/7	AIR	IAVWOPSG to periodically review Doc 9974 and, where necessary, recommend revision for the consideration of the Operations Panel.	Complete
3/8	AIR	States to reference Doc 9974, at a suitable version, as part of the material incorporated in their applicable State or Regional volcanic ash contingency plan or equivalent.	Complete
3/9	ATM	Making the finalized ATM volcanic ash contingency plan available to all ICAO regional Offices in view of supporting its consideration when developing regional volcanic ash contingency plans.	On-going ¹¹
3/10	ATM	Finalizing and processing of a proposed draft amendment to PANS-ATM (Doc 4444), 15.8 concerning procedures for an ATC unit when volcanic ash is reported or forecast.	On-going
3/11	IAVW	Discontinuation of work on developing modelled volcanic ash concentration information for users.	Complete

¹⁰ Refer to the [IVATF/3 List of Recommendations](#) for the full description of the recommendations.

¹¹ Follow-up was deferred beyond the 31 March 2012 deadline (Agenda Item 4.1 of IVATF/4 refers).

APPENDIX C

RECOMMENDATIONS FOR AIRCRAFT INSTRUMENTATION FOR CONDUCTING VOLCANIC ASH CLOUD SAMPLING

(Extracted from IVATF/4-WP/10)

The following recommendations for airborne sampling of ash plumes result from the experience with the Eyjafjallajökull eruption.

It is important to perform airborne measurements in the eruption plume as soon as possible after the eruption to get early information on the source term and ash properties. Therefore, research aircraft with suitable instrumentation should be available on a short notice (within 1-2 days). The aircraft should be capable of making measurements in the entire range of flight levels used by commercial air traffic, i.e. at altitudes up to 40,000 ft. It is recommended that experienced pilots and instrument operators conduct the missions. The crew on sampling flights should also carefully document their visual observations. The planning of the flights should be based on all information available including data from satellites, ground-based observing systems, and predictions from dispersion models.

The recommended instrumentation of the aircraft includes a combination of remote-sensing (Lidar, IR radiometer, DOAS) and in-situ measurement systems for particles and gas-phase plume tracer. The Lidar provides information on the horizontal and vertical extent of the ash plume with qualitative information on the ash concentration and serves as pathfinder for the in-situ measurements. For the in-situ sampling, the ash plume is best intercepted using a combination of stacked flight runs and vertical profiles covering the entire vertical extent of the plume. Thereby data are obtained that are best suited for comparison with satellite observations and dispersion models. Table 1 below provides a list of recommended instrument types and measurements that are currently available.

The mass concentration of ash cannot be measured directly but is determined from the particle-number size distribution measured with the wing-mounted optical particle counter for given refractive index and density of the particles. Therefore, it is important to cover the entire size range of ash particles in the plume. The resultant uncertainty in ash mass concentration is about a factor of 2 (Schumann et al., ACP, 2011).

<i>Instrumentation</i>	<i>Measured quantity</i>
Remote sensing instruments	
Lidar (down, up or ahead viewing)	Aerosol backscatter ratio, depolarization
IR remote sensing	IR radiance at different wave-length
DOAS	SO ₂ slant column density
In situ particle instruments	
Condensation particle counter (with heated and unheated channels) in aircraft cabin	Integral number of ultrafine particles ($0.005 < D_p < 2.5 \mu\text{m}$) and non-volatile fraction (sampled through inlet characterized for particle loss)
Optical particle counter (Grimm OPC 1.129) in aircraft cabin	Fine particles ($0.25 \mu\text{m} < D_p < 2.5 \mu\text{m}$), (sampled through inlet characterized for particle loss)
PCASP-100X/UHSAS-A (wing mounted)	Fine particles, dry state ($0.15 \mu\text{m} < D_p < 3.0 \mu\text{m}$)
FSSP-300/CAS (wing mounted)	Size distribution coarse mode, ambient state ($1 \mu\text{m} < D_p < 30/50 \mu\text{m}$)
2D-C probe/CIP-15 (wing mounted)	Shape and size distribution of very large particles, water droplets and ice crystals ($25 \mu\text{m} < D_p < 800 \mu\text{m}$)
Nephelometer	Particle scattering at three wavelength
Particle collection system (in cabin and wing mounted)	Chemical composition, particle size, shape, morphology (post flight analysis)
Trace gas in-situ instruments	
Chemical ionization mass spectrometer	SO ₂ , HCl, HF, HNO ₃ mixing ratios
UV absorption detector	O ₃ mixing ratio
Vacuum UV fluorescence detector	CO mixing ratio
Chemiluminescence detector	NO, NO _y mixing ratios
Meteorological data	
Standard probes	Position, temperature, pressure, humidity, wind

Table 1. Aircraft instrumentation for volcanic ash cloud sampling

APPENDIX D

PROPOSED ADDITIONAL TEXT FOR INCLUSION IN DOC 9691

Note.— Paragraphs 4.3.9 and 4.3.10 below are extracted from Amendment No. 3 to Doc 9691 (due for publication in mid-2012).

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Standard that has resulted in safe operations during volcanic eruptions

4.3.9 Since the introduction of the VAACs and the communication channels between them, the WMO and the aviation community, the number of significant in-flight volcanic ash encounters has diminished dramatically, even though the number of volcanic ash events has continued through the years. One key element that has enhanced operational safety (compared to the 1982 Galunggung volcano and 1989 Mt. Redoubt B747 events) has been the diligence and expertise of the VAACs and MWOs reporting on “observed” or “visible” volcanic ash clouds. These “observations” by the VAACs and MWOs have been primarily based on satellite imagery, either visual or infrared. This “observed” information has been used in correlation with dispersion models and meteorological expertise to forecast where a volcanic ash cloud will likely be several hours in the future. This use of a composite of all available information by meteorologists to forecast the location of a volcanic ash cloud has served aviation well. These observed reports and forecasts that are correlated to direct observations, along with operators avoiding flight planning or flights into “visible” or “observed” volcanic ash cloud, has resulted in safe and efficient operations in recent years. (It is important to note that there can be significant uncertainty in the forecast dispersion model predictions due to the inaccuracy of the source parameters (amount of debris ejected from the volcano, how high the debris was ejected, time since eruption, etc.) and the variation between forecast dispersion models used by different VAACs.)

4.3.10 The most significant hazard to an aircraft from a volcanic ash encounter is the impact on the engines and the potential consequent loss of all thrust. There are other significant hazards to the aircraft such as erroneous airspeed, but none of these hazards are catastrophic by themselves. Each of these other hazards can be mitigated through flight crew procedures or training that allows for continued safe flight and landing. As discussed in 4.2.5, today’s jet engines have demonstrated capability in low levels of volcanic ash concentrations (not visible), provided that operation in visible ash is avoided. However, there are a number of variables including cloud thickness, particle size and ash concentration that affect whether the ash is visible. In order to ensure safe and efficient operations, such information should be taken into account in a flight operation risk assessment as described in Doc 9974. It should also be noted that even operations in low levels of ash concentration (not visible) can result in increased maintenance costs due to accelerated aircraft and engine degradation.

[START OF NEW TEXT]

4.3.11 Volcanic ash shall – as a geophysical safety hazard – be addressed as an intrinsic element of the Safety Management System as required under ICAO Annex 6 Part I Operation of aircraft – Commercial Transport Aeroplanes, Part II – International General Aviation – Aeroplanes and Part III International Operation Helicopters – International Commercial Air Transport.

4.3.12 Guidance on Safety Management Systems can be found in the *Safety Management Manual* (Doc 9859) and the manual on *Flight Safety and Volcanic Ash – Risk management of flight operations with known or forecast volcanic ash contamination* (Doc 9974), which specifically addresses the risk of operations in airspace contaminated with volcanic ash.

4.3.13 For the types of operations which do not require an SMS, such as certain Search and Rescue or Medical Emergency or Evacuation operations, the States are recommended to consider the specific nature of the life-saving operations in order to allow for operations in emergency conditions in airspace contaminated with volcanic ash. A simplified Safety Risk Assessment with regard to the hazards of volcanic ash for these types of operations may be requested by the State of the Operator.

[END OF NEW TEXT]

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APPENDIX E

PROPOSED GUIDANCE FOR CONDUCTING VOLCANIC ASH EXERCISES IN ICAO REGIONS

1. Overview

1.1 Volcanic ash exercises should be conducted by ICAO on a regional basis in order to practice and develop inter-agency response to volcanic activity, in order to maintain safety, regularity and efficiency of aviation in the event of a volcanic eruption. This guidance recognizes that there is significant regional variation in the nature, frequency, observation of and response to volcanic eruptions. The frequency and scope of volcanic ash exercises is the responsibility of the concerned ICAO Region. Where frequent volcanic activity results in adequate information about system performance, exercises may be omitted or constrained to infrequent, extraordinary situations or be held only to test revised procedures.

1.2 Volcanic ash exercises should be facilitated via the concerned ICAO Regional Office and support the regular assessment of system performance (in accordance with quality management principles), in particular the assessment of the safety performance which is required by ICAO Safety Management provisions, such as ICAO Annex 11 – *Air Traffic Services*, 2.27.3c).

1.3 Reports of the exercises or performance assessments should be reviewed by an appropriate sub-group or sub-groups within the concerned ICAO Region. The focus of these reviews should be the development of improved provisions. Recommendations for improvements to global ICAO provisions, based on the regional review of the exercises, should be brought to the attention of the concerned ICAO Planning and Implementation Regional Group and/or to the International Airways Volcano Watch Operations Group (IAVWOPSG).

1.4 A Volcanic Ash Exercises Steering Group may be established by an ICAO Planning and Implementation Regional Group to co-ordinate all aspects of the organisation and conduct of the exercises. The steering group should have representatives from, as a minimum, concerned volcanic ash advisory centres (VAACs), air navigation service providers (ANSPs), airspace users and regulators.

2. Exercises and Performance Assessments

2.1 Volcanic ash exercises should be held at a frequency to be determined by the ICAO Region concerned. They should be held at least every three years where the frequency of real eruptions is low and additionally as soon as practicable when significant changes to the procedures have been implemented.

2.2 Volcanic ash exercises are designed to test volcanic activity alerting, aeronautical information service (AIS) and meteorological (MET) message routing, volcanic ash dispersion forecasts, air traffic control procedures, air traffic flow and capacity management and aircraft operator response and the Collaborative Decision Making (CDM) between the various actors in accordance with regional and global procedures.

2.3 Exercises can only simulate a real event, while operation of the aviation system must continue normally and be unaffected by the exercise. The planning of the exercise needs to ensure that detrimental effects on the system performance are avoided, but that nevertheless useful experience and information is generated.

2.4 A complete, system-wide, exercise for volcanic ash contamination is an extremely complex undertaking since such an event involves a great number and variety of stakeholders. It might therefore be useful to constrain exercises to specific parts of the whole system, with other parts of the system being subject to testing at subsequent exercises.

3. Objectives

3.1 The exercises should be designed to:

- a) Practice the conduct of volcanic activity response in accordance with the regional reference documents;
- b) Verify existing information, AIS and MET message routing via AFTN addresses, relevant e-mail addresses, telephone and fax numbers; internet addresses (URLs);
- c) Maintain appropriate information and message routing between all involved agencies and organizations;
- d) Provide volcanic activity response training for key personnel involved;
- e) Allow the regulators to assess the preparedness and operational response in terms of planning, process and procedures of operators; and
- f) Provide, when appropriate, recommendations for amendment of the reference documents, in accordance with the lessons learned and conclusions contained in the final exercise report.

3.2 Exercises may also be designed to test suggested new procedures on a limited scale before regional/global implementation.

3.3 Exercise and system performance assessments should be aimed at a critical review of existing provisions and their further improvement.

4. Concepts

4.1 Each exercise involves a simulated volcanic contamination (e.g. eruption of a volcano or re-suspended ash) affecting aviation. Simulated ash clouds may cross international boundaries, depending on the objectives of the exercise and may affect more than one VAAC area of responsibility. Exercises may utilise real-time meteorological conditions or archived data.

4.2 Each exercise may have different objectives, which the scenario will be designed to address. For example any or all of the activities listed below may be tested depending on the scope of the exercise:

- a) AFTN, e-mail addresses, websites, message routing and voice communications;
- b) Alerting and observation of ash (e.g. use of VONA and VAR);
- c) VAAC Response e.g. Volcanic ash dispersion forecasts and advice;
- d) ATS response (including ATC and AIS for NOTAM issuance);
- e) ATM response;
- f) Aircraft Operator response (including SRA);
- g) Met Watch Office response (i.e. SIGMET); and
- h) Suitability of information, its frequency, format and content.

5. Planning and Reporting

5.1 Each ICAO Region should establish an appropriate structure (e.g. focal point or steering group) for the conducting of regional volcanic ash exercises and system performance assessments. For each exercise, an exercise leader should be appointed and a planning meeting held approximately three months before the exercise is due to take place.

5.2 An exercise directive should be published prior to the exercise which clearly describes the exercise scenario, participating agencies and any special instructions.

5.3 After the exercise, initial exercise reports should be prepared by all participating agencies. A debrief meeting should be held soon after the exercise to discuss the exercise reports. The exercise leader should then produce a consolidated final exercise report for consideration by the relevant ICAO group.

6. ICAO reference material

- *Annex 3 – Meteorological Service for International Air Navigation*
 - *Annex 11 – Air Traffic Services*
 - *Annex 15 – Aeronautical Information Services*
 - *Procedures for Air Navigation Services – Air Traffic Management (Doc 4444)*
 - *Manual on Volcanic Ash, Radioactive material and Toxic Chemical Clouds (Doc 9691)*
 - *Global Air Navigation Plan (Doc 9750)*
 - *Handbook on the International Airways Volcano Watch – Operational Procedures and Contact List (Doc 9766)*
 - *Global ATM Operational Concept (Doc 9854)*
 - *Manual on Flight Safety and Volcanic Ash – Risk management of flight operations with know or forecast volcanic ash contamination (Doc 9974)*
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APPENDIX F

COMPARISON OF ICAO, EASA AND UNITED STATES FAA VOLCANIC ACTIVITY REPORT (VAR) FORMS

One part of the IVATF task TF-ATM03 is related to the improvement of the volcanic activity report (VAR) form and update of the taxonomy. Discussion during IVATF/2 (IVATF-2-WP/29 refers) highlighted that VARs serve three different purposes:

- a) Immediate notification of other aircraft about volcanic hazards;
- b) Input to the information chain for volcanic hazards; and
- c) Post-flight review of occurrences (including airworthiness related issues).

The table below contains a comparison of the VAR forms of ICAO, EASA and the United States FAA and includes the comments on the ICAO form contained in Appendix B to IVATF/2-WP/29. The objective of the comparison is to:

- identify reporting fields;
- present those which are covered by all forms or by one of the forms;
- show if the taxonomy used is covered by the ICAO ADREP taxonomy; and
- give the opportunity to develop a proposal for the most optimum VAR form.

No.	ICAO	IVATF/2-WP/29 Comments on ICAO form	EASA	FAA/Volcanic Activity Reporting Form (VAR)	ADREP Taxonomy
	Air-reports are critically important in assessing the hazards which volcanic ash cloud presents to aircraft operations.	Message should be enhanced to encourage potential reporters.	1. Reference Information		
1.	Operator		1.1 Operator		Yes – ID215
2.	A/C identification (as indicated on flight plan)	An ideal combined VAR should contain information on the aircraft and engine type and model	1.4 Flight Number		Yes – ID 54
3.	Pilot in command				Yes - ID 402
4.	Dep from/Date/Time		1.6 Departure airport/date/time		No
5.	Arr at/Date/Time		1.7 Arrival airport		No
6.			1.2 Aircraft manufacturer and type/model		Yes – ID 21
7.			1.3 Aircraft registration		Yes – ID 244
8.			2.3 Meteorological conditions (VMC, IMC)		Yes – ID127
9.			2.4 Light conditions (Daylight, Dusk/dawn, Night)		Yes – ID168
10.			3.4 Phase of the flight (Taxi, Take-off, Climb, En-route, Descent, Approach, Landing, Hovering, Ground handling, Unknown, Other, Specify)		Yes ID 121
11.	Addressee				No
12.	AIREP Special				No

No.	ICAO	IVATF/2-WP/29 Comments on ICAO form	EASA	FAA/Volcanic Activity Reporting Form (VAR)	ADREP Taxonomy
	Items 1-8 to be reported immediately to the ATS unit that you are in contact with		2. Conditions of encounter	Transmit to ATC via radio	
13.	1. Aircraft identification			1. Aircraft identification	Yes – ID54
14.	2. Position		2.2 Geographic position	5.Position/location of volcanic activity or ash cloud	Yes – ID440
15.	3. Time			3. Date/Time (UTC)	Yes – ID 457 and 478
16.	4. FL or Altitude		2.1 FL or Altitude	4. FL or Altitude	Yes – ID25
17.	5. Volcanic activity observed at (position or bearing, estimated level of ash cloud and distance from aircraft)	Change to "(position or bearing and distance from aircraft; estimated vertical and lateral extent of ash cloud, and, where possible, horizontal movement, rate of growth, etc)"			No
18.	6. Air temperature			6. Air temperature	Yes – ID287
19.	7. Spot wind			7. Wind	Yes – ID176

No.	ICAO	IVATF/2-WP/29 Comments on ICAO form	EASA	FAA/Volcanic Activity Reporting Form (VAR)	ADREP Taxonomy
20.	<p>8. Supplementary information (SO₂ detected Yes/NO, Ash encountered Yes/NO)</p> <p>Other: (Brief description of activity especially vertical and lateral extent of ash cloud and, where possible, horizontal movement, rate of growth, etc.)</p>	<p>Effects on aircraft need to be part of the items "to be reported immediately to the ATS unit"</p> <p>Some elements belong to item 5 in yellow (see comment there).</p> <p>The supplementary information should include "type of eruption (e.g. ash cloud, steam, lava flow, pyroclastic flow, ...)" and "shape of volcanic cloud (e.g. line of smoke; cone, mushroom, ...)"</p>		8. Supplementary information (Brief description of activity including vertical and lateral extent of the ash cloud, horizontal movement rate of growth, etc, as available	No
	<p>After landing complete items 9-16 then fax form to (Fax No to be provided by the meteorological authority based on local arrangements between the meteorological authority and the operator concerned.)</p>	<p>This text should be revised as follows: "Complete items 9 - 16 as soon as time permits after observation/encounter. After landing fax form to:</p>	<p>3. Ash description and encounter phase</p>	<p>Complete and forward as directed</p>	
21.	<p>9. Density of ash cloud (Wispy, Moderate dense, Very dense)</p>	<p>Explanations (definitions) for these terms should be added</p>	<p>3.3 Density of ash cloud (Wispy-thin, Moderate dense, Very dense)</p>	<p>9. Density of ash cloud (wispy, moderately dense, very dense,)</p>	No
22.			<p>3.5 Estimated duration of encounter (hh:mm)</p>		No

No.	ICAO	IVATF/2-WP/29 Comments on ICAO form	EASA	FAA/Volcanic Activity Reporting Form (VAR)	ADREP Taxonomy
23.	10. Colour of ash cloud (White, Black; Light grey, other; Dark grey)		3.2 Colour of ash cloud visible (White, light grey, Black, other)	10.Colour of ash (white, light grey, dark grey, black)	No
24.			3.1 Ash cloud visible (Yes, No)		No
25.	11. Eruption (Continuous, Intermittent, Not visible)			11.Eruption (continuous, intermittent, not visible)	No
26.	12. Position of activity (Summit, Multiple; Side, Not observed; Single)			12. Position of activity (summit, side, single, multiple, not observed)	No
27.	13. Other observed features of eruption (Lighting, Ash fallout; Glow, Mushroom cloud; Large rocks, All)			13. Other observed features of eruption (lightening, glow, large rocks, ash fallout, mushroom cloud, none)	No
28.	14. Effect on aircraft (Communication, Pitot static; Navigation systems, Windscreen; Engines, Windows)	This section (to be moved to item 8) should be expanded by "Electronic Systems (e.g. failure messages)" and "other component: - specify		14.Effect on aircraft (communications, navigation system, engines, pitot static, windscreen, other windows, none)	No
29.	15. Other effects (Turbulence, St Elmo's Fire, Other fumes)	What are "Other fumes" and what purpose shall this information have?	0. Electrostatic discharge (St Elmo's fire) on windshield, nose, or engine cowls	15. Other effects (turbulence, St. Elmo's fire, fumes, ash deposits)	No
30.	16. Other information (Any information considered useful)			16.Other information deemed useful	No
			4. Severity of encounter		
31.			0. Sulphurous odour noted in the cabin		No

No.	ICAO	IVATF/2-WP/29 Comments on ICAO form	EASA	FAA/Volcanic Activity Reporting Form (VAR)	ADREP Taxonomy
32.			0. Anomalous atmospheric haze observed		No
33.			0. Ash reported or suspected but no other effects or damage noted		No
34.			1. Light dust observed in cabin		No
35.			1. Ash deposits on exterior of aircraft		No
38.			1. Fluctuations in exhaust gas temperature (EGT) with return to normal values		No
39.			2. Heavy cabin dust (dark as night in cabin)		No
40.			2. Contamination of air handling and air conditioning systems requiring use of oxygen		No
41.			2. Abrasion damage to exterior surfaces, engine inlet, and compressor fan blades		No
42.			2. Pitting, frosting, or breaking of windscreen or windows		No
43.			2. Minor plugging of pitot-static system insufficient to affect instrument readings		No
44.			2. Deposition of ash in engine		No
45.			3. Vibration or surging of engine(s)		No
46.			3. Plugging of pitot-static system insufficient to affect instrument readings.		No

No.	ICAO	IVATF/2-WP/29 Comments on ICAO form	EASA	FAA/Volcanic Activity Reporting Form (VAR)	ADREP Taxonomy
47.			3. Contamination of engine oil or hydraulic-system fluids		No
48.			3. Damage to electrical, computer, communications or navigational systems		No
49.			3. Engine damage		No
			4. Temporary engine failure requiring in-flight restart of engine		No
			5. Further information and attachments		
			5.1 Description of occurrence		No
			5.2 Attachments (Photos, Sketch, Other, Specify)		No
			6. Contact information		
			6.1 Contact name		No
			6.2 E-mail address		No
			6.3 Telephone/Fax		No

APPENDIX G

WORK PROGRAMME OF THE IVATF

(as updated by IVATF/4)

1 TASKS ALLOCATED TO THE ATM SUB-GROUP

Task number (origin)	Sub-group/responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter- dependencies
TF-ATM01 (IVATF/1 updated at IVATF/2 and IVATF/3)		ATM Volcanic Ash Contingency Planning. Complete at IVATF/4 in view of the Agenda Item 4.1 and IVATF Recommendation 4/..				
TF-ATM02 (IVATF/1 updated at IVATF/2)		Other ICAO groups working on volcanic ash-related matters. Complete at IVATF/3 in view of the ATM SG progress report.				
TF-ATM03 (IVATF/1 updated at IVATF/2)		Communication chain regarding the collection and dissemination of pilots reports of volcanic activity. Complete at IVATF/3 from an ATM SG perspective. <i>Note — IAVW CG task TF-VAA12 updated at IVATF/3 to include an assessment of the ICAO, EASA and United States FAA volcanic activity report (VAR) forms in order to determine a single common format that has global application capability.</i>				
TF-ATM04 (IVATF/2)		EUR/NAT ATM Volcanic Ash Contingency Plan clarification with respect to the issuance of clearances through danger areas. Complete at IVATF/3 from an ATM SG perspective and in view of IVATF Recommendation 3/10. <i>Note — IVATF Recommendation 3/10 represents the finalizing and processing of a proposed amendment to PANS-ATM (Doc 4444), 15.8. The ATM SG recognized that a consequential amendment to the ATM volcanic ash contingency plan of the EUR/NAT Region (EUR Doc 019 / NAT Doc 006 Part II) will be necessary to accommodate the change in procedures within PANS-ATM, 15.8.</i>				
TF-ATM05 (IVATF/2, updated by IVATF/3)		Investigation of danger area terminology. Complete at IVATF/4 in view of the Agenda Item 4.2 and IVATF Recommendation 4/..				

Task number (origin)	Sub-group/responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter-dependencies
TF-ATM06 (IVATF2)		<p>Review of the issuance of aeronautical and meteorological messages in light of information overload concerns. Complete at IVATF/3 from an ATM SG perspective. <i>Note — Taking into consideration the progress report of the ATM SG at IVATF/3, the IAVW CG has been consequently tasked (under task TF-VAA13) to formulate proposals to reduce or eliminate information overload concerns during volcanic eruptions.</i></p>				

2 TASKS ALLOCATED TO THE AIR SUB-GROUP

Task number (origin)	Sub-group/responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter-dependencies
TF-AIR01 (IVATF/1 updated at IVATF/2 and IVATF/3)		<p>Define unsafe factors for operations in volcanic ash / Development of operationally applicable characteristics that can be used as a threshold value for the concept of ‘visible ash’. Complete at IVATF/4 in view of the Agenda Item 3.1 and IVATF Recommendation 4/..</p>				
TF-AIR02 (IVATF/1)		<p>Determine airframe, engine and components susceptible to ash/gas contamination. Complete at IVATF/2 in view of IVATF Recommendation 2/15.</p>				
TF-AIR03 (IVATF/1)		<p>Develop airworthiness criteria for States as a component of their decision concerning operations in airspace that is potentially contaminated with volcanic ash. Complete at IVATF/2 in view of integral component of IVATF task TF-AIR04.</p>				
TF-AIR04 (IVATF/1 updated at IVATF/2)		<p>Develop pre-flight/ dispatch guidance material and specific criteria to assist operators in their decision making process prior to operations in potential ash contaminated areas using risk management principles Complete at IVATF/3 in view of the action plan within the AIR SG progress report.</p>				
TF-AIR05 (IVATF/1 updated at IVATF/2)		<p>Review ICAO guidance concerning flight crew procedures in the event of an ash encounter. Complete at IVATF/4 in view of the Agenda Item 3.2 and IVATF Recommendation 4/..</p>				

Task number (origin)	Sub-group/responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter-dependencies
TF-AIR06 (IVATF/1 updated at IVATF/2)		Review guidance material on maintenance and inspection procedures appropriate for flight in ash contaminated areas / Review aerodrome procedures that may have an impact on airworthiness. Complete at IVATF/4 in view of the Agenda Item 3.3 and IVATF Recommendation 4/..				
TF-AIR07 (IVATF/1 updated at IVATF/2)		Study any potential certification implications. Complete at IVATF/4 in view of the Agenda Item 3.4 and IVATF Recommendation 4/..				
TF-AIR08 (IVATF/1)		Airworthiness effects associated with those flight operational scenarios judged by operators to be most likely to secure useful alleviations from flight restrictions during a future volcanic ash crisis / Establish an OEM crisis response plan. Complete at IVATF/2 in view of IVATF Recommendation 2/19.				

3 TASKS ALLOCATED TO THE SCI SUB-GROUP

Task number (origin)	Sub-group/responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter-dependencies
TF-SCI01.1 (IVATF/1 updated by IVATF/2)		Develop a table of capabilities and accuracies of ground-based detection methods. Complete at IVATF/4 in view of the Agenda Item 2.1 and IVATF Recommendation 4/..				
TF-SCI01.2 (IVATF/1 updated by IVATF/2)		Prepare training material on satellite remote-sensing techniques. Complete at IVATF/4 in view of the Agenda Item 2.1 and IVATF Recommendation 4/..				
TF-SCI01.3 (IVATF/1 updated by IVATF/2)		Guidance table concerning airborne sampling. Complete at IVATF/4 in view of the Agenda Item 2.1 and IVATF Recommendation 4/..				

Task number (origin)	Sub-group/ responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter-dependencies
TF-SCI02.1 (IVATF/1 updated by IVATF/2 and IVATF/3)		Evaluate volcano monitoring gaps worldwide / Produce a list of volcanoes that threaten aviation and are inadequately monitored. Complete at IVATF/4 in view of Agenda item 2.2 and the on-going work under IAVWOPSG Conclusion 6/23.				
TF-SCI02.2 (IVATF/1 updated by IVATF/2)		Encourage increased use of aviation colour code among Volcano Observatories. Complete at IVATF/3 in view of IVATF Recommendation 3/2.				
TF-SCI03.1 (IVATF/2 updated by IVATF/3)		Quantify the detectability of ‘visible ash’. Complete at IVATF/4 in view of the Agenda Item 2.3 and IVATF Recommendations 4/.., 4/.. and 4/..				
TF-SCI03.2 (IVATF/1)		Support requirements for airworthiness determination / Preliminary guidance on volcanic materials for engine testing. Complete at IVATF/2 in view of IVATF Recommendation 2/7.				
TF-SCI04.1 (IVATF/1)		Improved eruption source parameters for dispersion models. Complete at IVATF/2 in view of IVATF Recommendations 2/8 and 2/9.				
TF-SCI04.2 (IVATF/1 updated by IVATF/3)		Enhance MET data gathered during a volcanic event. Complete at IVATF/4 in view of the Agenda Item 2.4 and IVATF Recommendations 4/.., 4/.. and 4/..				
TF-SCI05 (IVATF/1)		Model improvements and validation. Complete at IVATF/2 in view of IVATF Recommendations 2/10, 2/11 and 2/12.				
TF-SCI06 (IVATF/1)		Health effects on aircraft occupants of exposure to volcanic sulphur dioxide. Complete at IVATF/2 in view of updated task TF-AIR05 within the AIR SG.				

4 TASKS ALLOCATED TO THE IAVW COORDINATION GROUP

Task number (origin)	Sub-group/responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter-dependencies
TF-VAA01 (IVATF/1)		<p align="center">Identification of volcanic ash-related guidance which needs to be updated. Complete at IVATF/2 in view of discussion under agenda item 5.1.</p>				
TF-VAA02 (IVATF/1 updated by IVATF/2 and IVATF/3)		<p align="center">Enhancement of VAAC products. Complete at IVATF/4 in view of the Agenda Item 5.1 and IVATF Recommendation 4/..</p>				
TF-VAA03 (IVATF/1 updated by IVATF/2 and IVATF/3)		<p align="center">Improved integration of collaborative decision-making within the IAVW. Complete at IVATF/4 in view of the Agenda Item 5.2 and IVATF Recommendation 4/..</p>				
TF-VAA04 (IVATF/1)		<p align="center">Transport and dispersion modelling. Complete at IVATF/2 in view of discussion under agenda item 5.3.</p>				
TF-VAA05 (IVATF/1 updated by IVATF/2 and IVATF/3)		<p align="center">Volcanic ash data files. Complete at IVATF/4 in view of the Agenda Item 5.3 and IVATF Recommendation 4/..</p>				
TF-VAA06 (IVATF/1 updated by IVATF/2 and IVATF/3)		<p align="center">Investigation on the provision of SIGMET information for large complex volcanic ash events Complete at IVATF/4 in view of the Agenda Item 5.4 and IVATF Recommendation 4/..</p>				
TF-VAA07 (IVATF/1 updated by IVATF/2 and IVATF/3)		<p align="center">Improvement to Volcano Observatory provisions. Complete at IVATF/4 in view of the conjoint follow-up with task TF-SCI04.2 (Agenda Items 2.4 and 5.5 refers)</p>				

Task number (origin)	Sub-group/responsibility	Task	Deliverable	Milestones (progress reports)	Expected completion	Inter-dependencies
IVATF/3)						
TF-VAA08 (IVATF/1)		Arrangements necessary to develop close cooperation between volcanological and meteorological agencies.				
			Complete at IVATF/2 in view of IVATF Recommendations 2/28 2/29 and 2/30.			
TF-VAA09 (IVATF/1)		Consideration of a need for the establishment of an office of volcanologists, under an international umbrella.				
			Complete at IVATF/2 in view of IVATF Recommendations 2/28 2/29 and 2/30.			
TF-VAA10 (IVATF/2)		Further development of a Concept of Operations for the IAVW.				
			Complete at IVATF/4 in view of the Agenda Item 5.6 and IVATF Recommendation 4/..			
TF-VAA11 (IVATF/2)		Development of volcanic ash exercise guidance.				
			Complete at IVATF/4 in view of the Agenda Item 5.7 and IVATF Recommendation 4/..			
TF-VAA12 (IVATF/2 and IVATF/3)		Improvements to the Volcanic Activity Report (VAR) form.				
			Complete at IVATF/4 in view of the Agenda Item 5.8 and IVATF Recommendations 4/.. and 4/..			
TF-VAA13 (IVATF/3)		Reduction or elimination of information overload during volcanic eruptions.				
			Complete at IVATF/4 in view of the Agenda Item 5.9 and IVATF Recommendation 4/..			