WORLD METEOROLOGICAL ORGANIZATION

International Union of Geodesy and Geophysics

International Civil Aviation Organization

Inaugural Meeting
Scientific Advisory Group on Volcanic Ash
(VA-SAG)

Montréal, QC, Canada

2-3 August 2010

FINAL REPORT

1. INTRODUCTION

At the 5th International Workshop on Volcanic Ash, organized by WMO in cooperation with ICAO and held at the kind invitation of Chile in Santiago de Chile from 17 to 21 March 2010, the formation of a Scientific Steering/Advisory Group was proposed in order to create a single, authoritative source of scientific expertise in the field of volcanic ash affecting civil aviation with emphasis both on meteorological (remote sensing and in-situ observations, transport and dispersion modeling) as well as geophysical/volcanological issues such as eruption source parameters, ash characteristics, ash fallout and aggregation. This expertise was to be made available to the relevant ICAO IAVWOPS group as a basis for future development of operational procedures, standards and guidance.

This proposal was subsequently adopted by the WMO Executive Council at its 62nd session in Geneva and fully supported by the Secretary General of IUGG.

The eruptions of the Icelandic volcano Eyjafjallajökull starting on 14 April 2010, leading to widespread airspace closures and unprecedented disruption to air traffic, prompted the formation of several national, regional and global groups and task forces under the egis of different governing bodies. ICAO decided to create an international Task Force on Volcanic Ash (IVATF) with the mandate to accelerate the production of guidance and standards in view of the serious effect of the aftermath of these eruptions on air traffic.

The inaugural meeting of the VA-SAG was thus timed to follow-on to the first meeting of the ICAO IVATF, held in Montreal from 27 to 30 July 2010, and was expected to respond to the questions and deliverables determined by the IVATF and its sub-groups.

2. SUMMARY OF DISCUSSIONS OF THE MEETING

2.1 Opening of the meeting

The meeting was opened at 09:00 on Monday, 2 August 2010, Room 7.15.55 of the ICAO Headquarters in Montreal. The participants were welcomed by the WMO Secretariat representative, Dr Herbert Puempel, Chief of the Aeronautical Meteorology Division, WDS Department. He thanked the participants for their willingness to devote time and effort not only to this meeting, but also to the deliverables that would be determined and agreed there, and ICAO for the kind offer to provide meeting facilities and excellent support through Mr Raul Romero, TO MET/AIM. He explained that the provisional agenda had to be prepared before the IVATF took place and invited the group to adapt the agenda in the light of the findings and decision of the IVATF meeting the previous week. The list of participants and the modified agenda are attached to this report as Appendix 1 and 2 respectively.

The meeting was then welcomed by Dr Olli Turpeinen, Chief of MET/AIM, explaining also the background of the cooperation between the different organizations involved, namely WMO, ICAO and IUGG. He offered his good services and wished the meeting best success.

In view of the necessary close cooperation between the VA-SAG and the IVATF, the meeting elected two co-chairs for the meeting and the ensuing work of the SAG, namely Dr Andrew Tupper, BoM Australia and long-standing member of the IAVWOPS as well as project manager for the coordination of IAVW in the IVATF, and Mr Larry Mastin, USGS, who has an outstanding record of contributions to the work of IAVWOPSG and is a close collaborator of the IVATF-SG Manager, Ms Marianne Guffanti,

The meeting took a short break at 09:45 before those members unable to attend physically would join in by teleconference at 10:00 hours. The meeting was joined by Prof. Ulrich Schumann (DLR Germany), Dr Gelsomina Pappalardo (Italy, chair of Earlinet and Galion), and Dr Sara Barsotti (Italian national volc. Survey), Mr Mike Pavolonis (University of Wisconsin) was travelling

back from Hawaii during the teleconference, but provided input by mail and would participate in the teleconference foreseen for Tuesday 3 August.

2.2 Introduction to the mechanisms of ICAO IAVWOPSG and IVATF

Andrew Tupper gave an overview of the IVATF meeting held in Montreal the week before. Marianne Guffanti provided the participants with copies of a Discussion matrix, outlining the deliverables of the Science subgroup of IVAF and the inter-dependencies with other groups, as well as links to the working and discussion papers reflecting the discussions there.

The meeting noted the large attendance at IVATF with around 100 persons, whereby the list of participants list of the IVATF included Task Force members and their advisors.

The documents of the IVATF meeting included Discussion Papers on the outcomes of the sub-groups, including deliverables and tasks for the groups.

Marianne Guffanti reported on deliverables for the science sub-group under her management. After 2 days of plenary sessions, the sub-groups worked for about 1 ½ days before re-convening in plenary on the afternoon of Friday 30 July. Participation in Sub-groups was self-assigned.

The Science Sub-Group, primarily tasked to look at observing and detection systems for volcanic ash, had also addressed dispersion modelling. The Discussion matrix presented was separating pre-eruption phase, Eruption Source Parameters, and the Volcanic Cloud at distal locations, and was ordered into the different methodologies for detection and modeling.

The meeting also identified a number of over-arching needs, such as the need for research data, meta-data describing content, format and characteristics of datasets, visualization of model and observations, as well as training issues.

The meeting was then presented with the corresponding Tasks Matrix, which focussed on the questions of what needs to be done in support of the IVATF, split into 5 sub-tasks. It was noted that external input was especially needed for the airworthiness task (on which volcanic material and how to test engines and airframes).

In order to better understand the context of the recent Icelandic eruption, a database of past ash encountered is to be published, addressing the question on quantification of past concentrations.

To complement existing work by Marianne Guffanti, Larry Mastin will contribute a re-construction of the KLM event, UKMO (Mat Hort) in collaboration with Rolls-Royce is working on similar datasets for some encounters.

Sara Barsotti mentioned the difficulty in determining ESP (Eruption Source Parameters) for Icelandic eruption, and underlined the need for the definition of scenarios.

Andrew Tupper then discussed the IAVW coordination group requirements. Science tasks in relation to the IAVW coordination, some further improvements to the information flow in the group is seen as essential.

He described the ICAO process where working documents are issued by Secretariat and modified by the meeting. Guidance material including training, competency standards, exercises, are all produced by the ICAO and WMO groups and secretariats based on the work of such groups.

All the encounter reports and data collected by ATM or IAVW should be shared with the SAG/SSG.

Finally, all requirements for warnings and products (to possibly include ash/aerosol concentrations) are to enter into the Standards of ICAO Annex 3. A fundamental discussion is taking place on the global way forward with respect to ash concentration limits vs. the binary ash/no ash model.

Andrew Tupper presented the view that there is a European contingency plan, but the global development may modify or revisit the current contingency plans.

A discussion followed on the comparability of the different models both in atmospheric and dispersion aspects, in particular ash removal processes, granularity/resolution, vertical layering and tendencies. There are still considerable differences in views and this subject requires further debate.

This group needs to come up with agreed capability statements. There will also be requirements for defining other aerosols as they may constitute a health or engineering risk together with ash.

The group discussed the issue of ash covered by ice/water etc. including the gaseous constituents, including difficulty of identifying sub-visible ice (Ash) cloud.

The need to assimilate observations into the dispersion models was seen as a fundamental issue, and also the “reverse engineering” to improve source parameters based on downstream observations.

Eruptive Column models are the next priority to address, questions of turbulence, wet deposition, are seen as more important than High Resolution atmospheric modeling around the source.

The group asked what lead time could be expected pre-eruption to prepare models, observing systems and operational response.

In the afternoon, the group was welcomed by the Director of the ICAO Air Navigation Bureau, Ms Nancy Graham, who underlined the importance of the work of the group and promised her full support for the group.

Following on, a presentation was given by Fred Prata (NILU) on the ESA Volcanic Ash Workshop held in Frascati in May 2010. The Draft Final report of this meeting is now available to the participants.

This meeting had been jointly organized by ESA and EUMETSAT and addressed a pre-defined set of questions, with a focus on observing platforms, models to improve VAAC products, future observation needs. Open questions include the “END OF ERUPTION” problem, and the issue of data being exchanged in non-standardized formats without corresponding metadata.

The Group requested that the Eyjafjallajökull encounter data collected by EASA be made available to the group, and Marianne Guffanti undertook to formally submit this request. The NILU presentation of SEVIRI-Based analysis showed the large variation of the source term and the move of the ash cloud over Europe.

Emphasis is placed on the physical properties of ash including refractive index particle size distribution etc. as subject for background research.

The VA-SAG noted with satisfaction the strong recommendation by the ESA meeting to respect the need for coordination with ICAO and WMO as global players.

A follow-up workshop is planned to take place in about a year’s time. It was proposed that SAG would interact with ESA/EUMETSAT to provide strong input for the programme selection for

this follow-up meeting. Fred Prata made a mention of the European Commissions FP7 call for icing and Volcanic Ash as a possible source of funding.

Following this presentation, Arnau Folch reported on the meeting of the European Volcanic Ash Cloud Experts Group (EVACEG) recently held under the auspices of the Spanish presidency of the EU.

This meeting had addressed the issue of ensemble/probabilistic modeling, with a discussion on relative merits and fundamental difficulties of combining several members of a model family (e.g. ECMWF) with independent data and the relative weights to be attributed to such ensemble members.

It was proposed that an eruption scenario development for known volcanoes could be done ahead of time, but it was recognized that remaining issues of water vapour content, wind shear etc. would need to be resolved. The use a “standard scenario” could be complemented with the preparation of some wider bands of mass flux values.

The question of the percentage of ash released by the umbrella cloud is open for further discussion.

There is also an intense discussion on the relative merits of near-field radars given the limited availability of such Radars currently (In Europe only Italy is operating one radar on a regular basis, and Iceland is planning to acquire a mobile unit for plume measurements. The situation is different for LIDAR, where a good network exists in Europe for aerosol measurements, but only isolated installations are operated in the other regions. The use of ceilometers is being investigated at least as a qualitative information for the lower troposphere. Operational use of LIDAR may be affected by a high persistent cloud cover during the cold season in many parts of northern and central Europe.

Questions were raised about the specifications, operational characteristics and experiences with radars used in Italy, and the alternative use of disdrometers, as well as the merits and roles of different radar types (X-, C, K-Band).

Andrew Tupper then went on to summarize the report of the 5th International Workshop on Volcanic Ash held in March 2010 in Santiago de Chile.

In the discussion, ash fall was mentioned as important “complementary information” about what is left in the atmosphere.

While lightning was mentioned in the Workshop report, the meeting noted an absence of the issue of charged particles, Icelandic report claims correlation between lightning and eruption strength, not really confirmed by other reports, doubts that it could be used to retro-guess ESP, but could be used to confirm ongoing eruption in the absence of other observations.

Inverse modeling by NILU (Fred Prata reported) for the Eyjafjallajökull eruption gave a source strength equivalent to 50% of the radar estimate, which given the fallout of larger particles near the volcano seems very reasonable.

The group recommended to contact WMO’s Commission for Basic Systems (CBS) for a suitable BUFR code table and reporting standards for volcanic ash (action WMO), and also check for links to Hyogo FWA in Disaster Risk Reduction.

Hans Schlager (DLR) presented a highly interesting series of graphics on the 17 Falcon Flights comparing in-situ and airborne LIDAR measurements, compared to ground-based LIDAR profiles and visual clues of the ash layers in photos taken from the cockpit. Several cases show also correlation between SO2 and ash fields, time-evolution of SO2 differential and CO with plume age.

The data will be submitted for publication within the next few weeks, probably in a special edition of Atmospheric Chemistry and Physics.

Larry Mastin (USGS), IMO and Matt Hort (UKMO) will cooperate with DLR on finding a best estimate of the source term of the past eruptions to allow a comparison of measurements and predictions of ash. With age of plume, errors due to aggregation and elimination of ash increase and need to be better estimated.

The meeting underlined the importance of comparisons to satellite data (MSG, GOME-2, OMI, MODIS), Ground-based LIDARS for calibration and better understanding of characteristics.

The meeting felt that it needed access to engineering considerations of what effect different ash/aerosol compositions can have on engines. In order to achieve comparability of data from different sources, there was agreement on the need for the development of a standard instrument set-up for future missions, and that Dropsondes for use on high-flying research aircraft should be developed.

Furthermore, it was felt that it was important to improve situational awareneness and the internal alert cycle to avoid time losses (e.g. IMO informing all parties in parallel), running routine forecast scenarios to gauge risk for German airspace.

A second teleconference was held from 10:00 to 11:30 Eastern Standard Time on 3 August, with participation by U. Schumann, Sara Barsotti, Gelsomina Pappalardo, and Mike Pavolonis .

During this teleconference, a discussion of Tasks and Assignments was held based on Marianne Guffanti's task list /matrix.

The tasks and the experts responsible for their completion were defined as shown in the following item.

3. ACTION ITEMS AND RESPONSIBILITIES FOR THE TIME BEFORE THE NEXT MEETING OF THE VA-SAG

Task 3 (Support to requirements for air worthiness) going to **Marianne Guffanti** with help from **Larry Mastin, Chris Newhall and Tom Cassadevall.**

Task 5 (Model improvements and validation) presented by **Andrew Tupper**, posing the question of what can be realistically done in the near term, particularly in support of VAAC London, who will be taking an active role in this task. This may include advice on feasible new products for aviation users, focussing on optimal use rather than writing new model code. There is an e-mailed offer by **Peter Webley** to help with this task, including help in evaluation of models against (Sat) observations. Attention is drawn on the Tephra modelling workshop on 18-20 October at WMO, but the progress report back to SSG of IVATF due on 13 Oct. Ulrich Schumann proposes a focus on model comparison to measurements e.g. by VAAC, **Arnau Folch** is commenting that such comparisons are planned for the WMO workshop, and thus volunteers to take care of this task. **Gelsomina Pappalardo** will also contribute LIDAR data, and **DLR** will contribute flight data. There is agreement on the need to consolidate the debate on methodology (what can be compared, 4d-position or concentration??)

Task 4 (Eruption Source Parameters) is offered by **Larry Mastin**, to cover mass flux, height, granularity, size distribution, flux variability, including the importance of obtaining a quick-look of the conditions a short way downwind of the volcano for VAAC purposes, whereby local operators and communities will require near-field information including ash fall. **NILU and UKMO (Matt Hort)** will contribute, mentioning the question of cost-effectiveness of HR modelling near the source from a VAAC point of view. **P. Webley** again a possible source of help.

Task 2 (Improve situational awareness) addressing the need for pre-eruption warnings requires volcanology experience, initially **Marianne Guffanti with Larry Mastin and Andrew Tupper** relying on support from USGS and WOVO. Relevant VAAC may be asked to run scenarios ahead of time.

Task 1 (Ways and means to improve VA cloud detection/avoidance systems for pre-flight and en-route decisions) A proposal by Fred Prata was accepted to sub-divide this task into 3 sub-tasks, seeing that modeling is already well covered by task 5.

Three sub-task leaders will be needed:

- **Gelsomina Pappalardo** was suggested for **ground-based**;

- **DLR (Ulrich Schumann and Hans Schlager)** for **air-borne measurements**;

- **Mike Pavolonis** for **space-based sensing**; and**,**

- **Fred Prata will** take overall responsibility **as Task leader**.

Marianne mentioned that there may be other questions arising form other IVATF sub-groups such as the question of visible ash.

Fred Prata is offering to establish a web site at NILU for documents that are secure for internal use of the group, which is welcomed by the group.

Gelsomina Pappalardo also offered to act as link to the WMO/GAW aerosol working group, which was happily accepted by the group, and she was asked to organize general feedback from the GAW aerosol group that is relevant to the VA issue.

A suggestion for the creation of a **Forum with the Web site to be hosted by NILU was welcomed** by the group. This would serve as an exchange platform. Teleconferences an option, but the geographical /time zone problem is noted as a serious problem.

Larry Mastin raised the question on the deliverables for the “final reports”. The model of “questions and answers” is being considered, but questioned as to time efficiency.

The process of getting changes into ICAO Annex 3 was discussed, for ash issues basically 1 June 2011 will be a crucial date for entering into the next IAVWOPSG in September for subsequent inclusion in the AMD 76 of Annex 3.

The group as a whole is expected to come up with a number of questions to be answered, and suggestions for subjects of the WMO Tephra modelling workshop.

The group was reaching an agreement that, in light of the long-standing request for ash tolerance data from OEM’s, the goal will be to establish the feasibility of quantitative ash forecasts including regional differentiation and uncertainty estimates. This feasibility with related uncertainty estimates will help ICAO and civil aviation authorities a clear basis for deciding upon a global volcanic ash response in terms of Guidance and Standards with regional specifications depending on atmospheric predictability and availability, completeness and accuracy of eruption source parameters.

4. DATES AND PLACE OF THE NEXT MEETING

It was decided that the next EGS meeting in Vienna, Austria would be an ideal venue and so the dates for the next meeting were fixed for 8 and 9 April 2011. **Herbert Puempel volunteered** to find a reasonable meeting venue outside the EGS, for example at ZAMG or ACG.

The report back to the IVATF should be kept concise (typically <30 pages), non-technical, should contain information on the “state of he art” at the current VAACs, and describe the “cutting edge” of existing modelling capabilities, including ensemble techniques. The meeting was reminded by Matt Hort and Arnau Folch of considerable computational resources for the ensemble, noting also that currently the scientific basis for ESP variations was not yet established.

There remained the questions of “VISIBLE ASH”, scenario design, “optimal” observing system, quick wins etc that should be also included in the report, probably organized as answers to FAQ.

The reports will cover the following environments:

1) pre-eruptive
2) near-field
3) far-field

The two co-chairs, who will work with **Marianne Guffanti,** will prepare an outline for each of the reports by **17August**, including the key questions to be answered by the reports.

The 6 April progress report will preview the progress of the April 8-9 Vienna meeting.

Matt Hort will update the list of VA related meetings for distribution to the group.

5. CLOSURE OF THE MEETING

The meeting closed after the customary exchange of courtesies at 15:00 hours on Tuesday 3 August 2010.

APPENDIX 1

WMO/IUGG VOLCANIC ASH SCIENTIFIC ADVISORY GROUP
Inaugural Meeting
Montreal, QC, Canada
2-3 August 2010

List of Participants

1. MEMBERS

Name	Country
Andrew TUPPER (Dr)	Australia
Alain MALO	Canada
Hans SCHLAGER (Dr)	Germany
Fred PRATA (Dr)	Norway
Arnau FOLCH (Dr)	Spain
Matthew HORT	United Kingdom
Larry G. MASTIN	United States
Marianne GUFFANTI (Ms)	United States
PARTICIPATION TELECONFERENCE ONLY	
Sara Barsotti (Dr)	Italy
Gelsomina PAPPALARDO (Ms)	Italy
Ulrich SCHUMANN (Prof.)	Germany
Mike PAVOLONIS	United States

2. OTHER PARTICIPANTS

Name	Country / Organization
Nancy GRAHAM	Director ANB - ICAO
Olli M. TURPEINEN	Chief, MET/AIM – ICAO
Greg BROCK	ICAO – EUR/NAT
Raul ROMERO	ICAO – IAVWOPSG

3. WMO SECRETARIAT

Name	Title
Herbert PUEMPEL (Dr)	Chief, Aeronautical Meteorology Division, WDS

WMO/IUGG VOLCANIC ASH SCIENTIFIC ADVISORY GROUP
Inaugural Meeting
Montreal, QC, Canada
2-3 August 2010

AGENDA

1. Opening of the meeting

2. Election of chair and co-chair of the meeting

3. Review of the outcomes of the IVATF, held 27-30 July 2010

4. Develop deliverables in terms of:

   Review of existing and emerging techniques in VA detection, eruption source parameter quantification, Tephra modeling, Transport and dispersion modeling

5. Develop a preliminary work plan and distribution of tasks

6. Date and place of next meeting

7. Any other business

8. Closure of the meeting