

WORLD METEOROLOGICAL ORGANIZATION

WMO VAAC "BEST PRACTICE" WORKSHOP 2016

**Servicio Meteorológico Nacional
Buenos Aires, Argentina**

25-27 April 2016

FINAL REPORT



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GROUP PICTURE



1. WORKSHOP OPENING AND ATTENDANCE

1.1. Dr Andrea Celeste SAULO, Director of the SMN and Permanent Representative of Argentina with WMO (World Meteorological Organization) opened the workshop and welcomed the participants. Mr Dimitar Ivanov, Chief of the Aeronautical Meteorology Division, WMO (C/AEM) welcomed everyone on behalf of the WMO Secretary-General and expressed thanks to the National Meteorological Service of Argentina for hosting the workshop and for the excellent working arrangement provided. The meeting was also addressed by Mr Peter Lechner, Chair of the ICAO MET Panel, Mr Raul Romero representing the ICAO (International Civil Aviation Organization) Secretariat and Mr Graham Rennie representing the IATA (International Air Transport Association).

1.2. Mr Ian Lisk, Vice-president of the WMO Commission for Aeronautical Meteorology (CAeM) chaired and moderated the workshop assisted by Mr Dimitar Ivanov.

1.3. The meeting was attended by representatives of all the nine VAACs, representatives of ICAO, IATA, USGS (United States Geological Service), US FAA (Federal Aviation Authority), WMO and experts from the host organization SMN (Servicio Meteorologico Nacional). A list of participants is given in Appendix A.

2. AGENDA AND OBJECTIVES

2.1. The meeting adopted the agenda presented in Appendix B.

2.2. The objectives of the workshop were to discuss improved processes to achieve volcanic ash service delivery harmonization and to follow on the outcomes of the previous Best Practice Workshops.

2.3. It was recalled that the following VAAC (Volcanic Ash Advisory Centre) 'best practice' statement was agreed at IVATF/4 (International Volcanic Ash Task Force) in Montreal in June 2012:

VAAC best practice is the expert evaluation of the best available sources of meteorological and volcanological information i.e.

- *Qualitative and quantitative satellite data;*
- *Model output;*
- *Ground and airborne based in-situ and remotely sensed observations;*
- *Pilot reports*

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

2.4. The workshop scope was broadly agreed to cover:

- Harmonization and consistency of service delivery;
- Sharing of best practice;
- Forecast continuity based on best data;
- Confidence at T+0 and how to better define uncertainty in subsequent forecasts;
- Evidence we use to back-up decisions we make – quality of evidence varies around the world;
- User needs – recognising that a big challenge is how to better manage users' expectations.

3. REVIEW FOLLOW-UP OF THE VAAC BP/3 (2015)

3.1. The meeting reviewed the actions arising from VAAC-BP/3 (2015). The agreed status of these actions is provided in the Table of Outcomes in Appendix C.

3.2. The meeting expressed concern regarding the very complex structure of the different bodies dealing with volcanic ash matters within WMO and ICAO. To understand better the scope and responsibilities of these bodies and their interlinkages and links with other relevant external bodies, it was agreed to prepare a schematic representation to be provided to the VAACs for better awareness.

3.3. The meeting also noted that WMO and ICAO are working on updating the working arrangements between the two organizations. This presents an opportunity to also rationalize the relationship between the working groups of the two organizations to in order to reduce duplication, possible confusion of roles and to make more efficient use of available resources.

4. VOLCANIC ASH FORECASTING IN SOUTH AMERICA

4.1. Dr Estela Collini presented on [Activities and challenges to face the detection of volcanic ash at SMN](#).

4.2. Mr Lisk congratulated Dr Collini on her presentation and expressed how impressed he was with the amount of excellent science being undertaken and coordinated by SMN. It was agreed that the challenge now, as in so many areas of innovative science, was how to transfer and apply this excellent science into the everyday operations of VAAC Buenos Aires.

5. MODELLING

5.1 Dr Matthew Hort presented on [Operational Model Configuration](#). Dr Hort summarized the range of recommendations arising from the Inputs and Outputs (Ins and Outs) VAAC Modelling Workshop that took place in Washington DC in November 2012 together with a 2016 update of the VAAC operational modelling configurations and settings.

5.2. Dr Alexander Baklanov (WMO Research) informed on activities by WMO GAW Science Advisory Group on Near Real Time modelling application (SAG-NRT). Cooperation with VAACs would be beneficial to understand how the dispersion models being used by the VAACs – both Lagrangean and Eulerian could benefit from improved strategies for data assimilation, etc. He also stressed that there should be better internal coordination within WMO of different groups addressing similar issues, e.g., the on-going activities in sand and dust storm forecasting.

5.3. Mr Graham Rennie (IATA) pointed out that users have a number of issues with modelling, i.e., issues with consistency amongst different models; issues with understanding what the (discernible ash) line means in terms of ash thresholds and whether these thresholds are consistent amongst the VAACs. Airline operators have to conduct safety risk assessment based on model data which is why they need a consistency of approach. Also, the quality of the NWP output varies in different regions vary, e.g., issues with lower quality in the tropics.

5.4. There was general agreement that the underpinning NWP continues to improve, however the existing gaps need to be highlighted and users informed. Among the gaps was the poor resolution of orography which leads to lower quality of the products over complex terrain.

6. RE-SUSPENDED ASH

6.1. Ms Paula Acethorp presented on [Forecasting Re-suspended Ash Events](#). Large areas of existing ash are known to re-suspend in certain meteorological conditions and all VAACs treat re-suspended ash as any other ash cloud and would issue a VAA to advise users of it. To alert users on the fact that it is a re-suspension event and not a new

eruption, mention of re-suspension can be made in either the "eruption details" field and/or the VAA (Volcanic Ash Advisory) RMK field. It was suggested that using the "eruption details" section for the re-suspension alert (with further details added into the RMK field if necessary) would be a suitable way to preserve space in the RMK field for other information. Modelling ash re-suspension requires knowledge of the area of ash that is capable of being re-suspended and being able to model the dispersal of that ash given the right meteorological conditions – only some VAACs currently have this capability. For ash fields at high risk of re-suspension, daily dispersion model runs have been implemented such as for Iceland by VAAC London..

6.2. It was highlighted that existing ash from very old eruptions may still cause problems. The potential for such ash to be re-suspended depend on many parameters, such as soil moisture, vegetation, presence/lack of snow, etc. This makes the assessment of the risk of re-suspended ash very difficult. However, it is important for airport managers to know the potential risk of re-suspended ash events based on wind forecasts and other available parameters.

6.3. Generally, re-suspended ash events affect lower atmosphere (e.g., up to 3-4000 m), thus it may be of little or no concern for en-route traffic. Ian mentioned a case for an Icelandic event when only a SIGMET was issued but not a VAA.

6.4. Realizing the need for a harmonized practice in describing re-suspended ash events, the meeting requested further guidance from the ICAO METP (Meteorological Panel) WG-MOG (Meteorological Operations Group) on the requirements and procedures to be followed concerning the issuance of VAA and SIGMET in such cases.

7. T+24 TRIAL UPDATE

7.1. Ms Yohko Igarashi presented an [Update on T+24 Trial](#). She highlighted a number of open questions concerning the status of the trial, eventual operationalization and related procedures.

7.2. The main issues with the T+24 were related to the low confidence of the T+24 forecast, but also with additional work load and cost. Mr Rennie reinstated that there is a user requirement for T+24 forecast which may not be directly related to the flight planning but to airlines' considerations like crew movement.

7.3. To resolve these uncertainties, it was suggested to seek advice from METP WG-MOG regarding the further steps with the T+24 trials and eventual inclusion of requirements for such forecasts in the coming Annex 3 amendments.

8. VAAC BACK-UP ARRANGEMENTS

8.1. The current situation with the VAAC back-up arrangements was reviewed. It was recalled that the VAAC BP/3 workshop (2015) requested all VAACs to review and update with email to Mr Raul Romero the table 4.3 in ICAO Doc 9766 concerning the VAAC back-up. It was suggested that the back-up arrangements should be tested at least annually with the respective OPMET databanks and MWOs (Meteorological Watch Office) feedback coordinated by VAACs.

8.2. The task was not completed at the time of VAAC BP/4, therefore, the respective action is reinstated as an outcome of the current workshop and VAACs were encouraged to follow up.

9. JET ENGINE IMPACTS

9.1. Dr Rory Clarkson presented on [Ash deposition and what damage this can cause the engine](#). Initial results from the VIPR-III (Vehicle Integrated Propulsion Research)

testing are now publicly available; a total running time of 7 hours was completed at 1 mg/m³ and 7 hours at 10 mg/m³. After 7 hours cumulative running at the lower concentration there was some evidence of a small amount of ash deposition in the engine's hot section but no detectable deterioration in performance. During the higher concentration running, there was a gradual and detectable deterioration in engine performance, but insufficient to justify a premature engine shutdown. NASA (National Aeronautics and Space Administration) will be issuing a detailed report on the testing in mid-2016.

9.2. Detailed engine data from the Kelud 2014 encounter is still pending; if this information could be made available, it would significantly enhance the understanding of volcanic ash impact on engines. There had been no reported in-service volcanic ash encounters worthy of investigation since 2014. However there have been some sand and dust related events that are providing significant quantitative insight into damage mechanisms. The similarity or otherwise of sand, mineral dust and volcanic ash with respect to engine damage was discussed; there is growing evidence from a fundamental science perspective as well as operational experience that sand, mineral dust and volcanic ash have overlapping characteristics. Two characteristics that potentially distinguish ash from sand and dust are; (i) there is some evidence that ash can be several factors more erosive in compressors than sand or dust, (ii) only volcanic eruptions are capable of generating particulate concentrations greater than a few 10s or 100s of mg/m³ at altitudes greater than a few hundred feet.

9.3. Data points relating to the VIPR-III testing, the Kelud 2014 and Soputan 1985 encounters and a sand and dust encounter considered relevant have been entered on the Rolls-Royce 'DEvAC chart'. Rolls-Royce is working with statisticians at University College London to investigate whether sufficient data now exists on the DEvAC chart to undertake a rigorous statistical analysis of damage levels.

9.4. Dr Clarkson also gave a brief summary of the regulatory developments in recent years, in particular the need to comply with the new EASA (European Aviation Safety Agency) requirement to declare airframe and engine volcanic ash susceptibility. One airframe engine combination has already submitted a proposal to EASA and another will do so shortly. Initial indications from EASA are that a declaration that the airframe and engines are susceptible to volcanic ash will be an acceptable declaration of susceptibility.

9.5. Mr Rennie (IATA) requested clarification concerning Rolls Royce likely response to EASA's volcanic ash regulatory requirements with a statement to the effect that operators should not operate in areas of visible or discernible ash. IATA's concerns related to the 'discernible ash' definition effectively being a proxy for an ash concentration of 0.2 mgm⁻³ or an order of magnitude less than the 2 mgm⁻³ which is the 'Medium ash concentration' that is currently used to inform the use and implementation of the VA Safety Risk Assessments in the EUR/NAT VA Contingency Plan. The group recognized these concerns and that the OEMs (Original Equipment Manufacturers) be further encouraged to develop VA impact 'threshold(s)' to supplement the detection-based thresholds currently being used by the VAACs.

10. T+0 CONFIDENCE AND PRODUCTS

10.1. Dr Emile Jansons presented on [Confidence in the VAAC's T+0 Assessment](#). He recalled the history of the discussion on confidence since the VAAC BP/1 in 2012. VAAC BP/2 agreed on using only two confidence levels *low* and *high*. IAVWOPSG/8 (International Airways Volcano Watch Operations Group) in February 2014 agreed on the definitions of "*High confidence*" and "*Low confidence*". Further on, VAAC BP/3 agreed that VAACs should collaborate on development of a T+0 volcanic ash 'confidence' graphical product proposal, based on the Best Practice 'Evidence Checklist'. During the IWVA/7 (International Workshop on Volcanic Ash) in Anchorage, in October 2015 VAACs agreed

to use the RMK section of the VAA and VAG (Volcanic Ash Graphic) for information on confidence level.

10.2. All VAACs reported the current status of their procedures for the inclusion of confidence level information and eventual feedback from users. There was a general consensus that VAACs are ready to use the confidence level, however, there were a number of open issues. Training material for forecasters is being developed and will be made available on the VAAC Darwin website.

10.3. The meeting recalled that Annex 3 currently does not state any requirement for the provision of confidence level in the VAA, which was also related to the development of guidance material. Thus, the issue should be referred to the METP WG-MOG. The following course of action was agreed:

- a) Prepare guidance material on the assessment and interpretation of T+0 confidence levels for the consideration of the ICAO METP, with a view to inclusion in ICAO Doc 9766;
- b) Reference T+0 confidence guidance material on each VAAC operational webpage;
- c) Subsequently commence the routine inclusion of a confidence statement at the beginning of the remarks section, using one of the statements: T+0 CONFIDENCE HIGH or T+0 CONFIDENCE LOW, as appropriate; and
- d) Collect feedback from users of the VAA on the utility of the T+0 confidence assessment/guidance material and report back to the WG-MOG.

10.4. The guidance material on confidence will be hosted by VAAC Darwin and referenced to all other VAACs websites.

10.5. It was recommended to look at the recently adopted "MET Information for TBO (Trajectory Based Operations) Concept" which contains relevant references to the use of confidence levels of the MET (meteorological) information to be provided in support of trajectory-based operations.

11. DISCERNIBLE ASH & VAG CONSISTENCY

In relation to VW3-O-03 (VAAC BP Workshop – Outcome-...), VAAC Forecast Process Best Practice 'guidance manual' to be developed with 'Discernible Ash Agreed techniques' section duplicated in Volcanic Ash Handbook, VAAC Tokyo and VAAC Darwin have agreed to take the lead of that task.

12. VAAC INFORMATION SHARING

The VAACs explored the possibility of using a common website for exchanging model output and other relevant information used in operational responses. A prototype developed by NOAA (National Oceanic and Atmospheric Administration) ARL (Air Resources Laboratory) was examined as well. While the idea of a platform for sharing information was found to be useful and the work done on this prototype appreciated, none of the VAACs are in a position to take on the responsibility for the maintenance and development of this site. As a result, it was proposed to explore other options for sharing of information. This includes, but is not limited to, social media platforms such as 'Facebook', 'WhatsApp' and others. The VAACs will look into the possibility of using such platforms and report back to the next best practices meeting. Barring the adoption of such a platform, the fallback option would be email and phone, despite some limitations associated with each of these (linguistic barriers, volume of messages, etc.). The VAACs are all aware of the "Volcanic Clouds" discussion group and found that a subscription to this group from an operational address is often a good source of information for real-time responses.

13. VAAC PRODUCTS IN XML (Extensible Markup Language)

13.1. The meeting was informed that WMO was about to publish the ICAO Meteorological Information Exchange Model (IWXXM) Version 2.0 Release Candidate 1 (RC1) for consultation. This version supports three new types of information: AIRMET, Tropical Cyclone Advisory (TCA) and Volcanic Ash Advisory (VAA). Details of IWXXM (ICAO Meteorological Information Exchange Model) 2.0RC1 including schemas, schematrons, examples, tutorial and other references could be found at the WMO WIS Wiki page at:

<http://www.wmo.int/pages/prog/www/WIS/wiswiki/tiki-index.php?page=IWXXM-2>.

13.2. VAACs exchanged information on their preparation for producing the information included in the VAA in XML using IWXXM-2.0. VAAC Darwin has already prepared a template for VAA in XML and provided some examples.

13.3. Noting that the IWXXM 2.0RC1 will be available for comments very soon, all VAACs were invited to review the draft once it is made officially available on the WMO website and provide comments. Such comments will be reviewed and taken into account in preparing the final draft for submission to the CBS-16 (Commission for Basic Systems) Session in November 2016. The final approval of the IWXXM 2 will be done by the WMO EC-69 (Executive Council) session in June 2017.

14. VONA AND ESP BP

14.1. Dr Dave Schneider presented on [Status of VONA](#) and [Global Eruption Source Parameter Database](#).

14.2. **Discussion on VONA.** There was an agreement to put VONA (Volcano Observatory Notice for Aviation) in the Handbook and a reference to it in Annex 3. IVATF discussed the possibility for respective international arrangements. ICAO has some power to progress the implementation, however, WOVO has no such power.

14.3. The workshop was reminded that the main purpose of VONA was to help 'NOTAM' offices with the issuance of NOTAMS relating to volcanic eruption status. NOTAMS are global and come automatically to flight planning systems. At the same time, VONA information is useful for the VAACs. The main issue is communication.

14.4. Mr Rennie expressed a concern that operators were being left out of the loop on these discussions. Where VONA are issued they are very informative and useful for airlines and so in addition to being disseminated to Air Traffic Control Centres, Mr Rennie highlighted the need for VONA to be disseminated to operators.

14.5. Dr Jansons informed the workshop about the work VAAC Darwin did in Indonesia on using the VONA. The local arrangements are that the NOTAM offices are not on the distribution list and there are no VA (Volcanic ash) NOTAMS issued. There may be some editions to the format to make it more useful, e.g., an important information would be the expected behaviour (TREND like) which would be very useful for the VAAC. Mr Peter Lechner informed the workshop that in New Zealand there is a different format for providing information on volcano eruption.

14.6. Mr Lisk highlighted how the VONA is used in a pseudo-regulatory way to support the EUR/NAT VA CP (European North Atlantic VA Contingency Plan), in particular the pre-eruption phases of escalating activity. Learning on the different views on the procedures and use of VONA in different parts of the world, the meeting should discuss whether there was a need to revisit VONA (also with reference to a paper from Mr Klaus Sievers). This includes considerations relating to common colour code definitions, target stakeholders, etc. Such considerations need to be discussed by the WG-MOG.

14.7. The meeting was aware of the inconsistent use of the colour code. For airlines, the colour code was not considered as operational info; the need to include the colour code in the VAA was questioned. Ms Igarashi informed the workshop that she had submitted a WP for WG-MOG which expressed the view that the use of colour code in the VAA could cause confusion and so the use of VONA should be optional.

14.8. **Discussion on ESP (Eruption Source Parameters).** The Global Eruption Source Parameter Database presented by Dr Schneider was considered as complementary to the Smithsonian database. Another database was being developed in the FutureVolc project, <http://futurevolc.hi.is/>. The main purpose of all these developments was to provide better default parameters for each volcano.

14.9. VAACs expressed their interest in the further development of the database and requested more information on how to use the database. It was agreed to conduct a survey with the VAACs mainly targeting the dispersion modellers and to use this information in deciding on the future use of the databases.

15. PRODUCTS IN SUPPORT OF IMPROVED SITUATIONAL AWARENESS

15.1 Mr Anton Muscat presented on [Products in support of improved situational awareness](#).

15.2. Safety Risk Assessment (SRA) charts based on VA concentration values have been provided by VAAC London and VAAC Toulouse and are referenced in the EUR/NAT VA CP. Recognizing the difficulties and shortcomings of the model concentration chart based approach, it has been proposed to replace the concentration charts with VA contamination charts using a total ash-column based approach. Possible formats of VA column mass loading (CML) charts were shown.

15.3. Mr Romero pointed out that the products described by Mr Muscat were not ICAO products and warned of potential confusion of users when using non-standard products. Thus, he advised that this type of information delivery should be labelled as Met Office and Météo-France not to be confused with the IAVW products delivered by the VAACs.

15.4. Further example of supplementary product was shown by Dr Jansons – an approach to indicate T+0 confidence in the VAG by colour coded polygon edges. Ms Igarashi presented the new [JMA volcanic ash data assimilation system](#) (Japanese Meteorological Agency).

15.5. It was agreed that VAACs should collaborate in the development of proposals for future 'supplementary' volcanic ash products. The assessment of such new products should be done through VASAG, followed by submission to the METP WG-MISD (Meteorological Information and Services Development) for inclusion in the planning for further enhancement of the IAVW information and services.

16. GLOBAL ATMOSPHERIC WATCH APPLICATIONS

16.1. Dr Baklanov from WMO Research Department presented on [WMO GAW Programme Applications](#) (Global Atmospheric Watch) and its possible applications for the volcanic ash community (VAAC, VASAG (VA Scientific Advisory Group), etc.).

16.2. The activities of the GAW Aerosol Lidar Observation Network (GALION), the Aerosol Science Advisory Group (SAG) and new Near Real Time (NRT) Modelling Application SAG were presented. It was stressed that GALION - a fundamental component of an integrated global observing system - can be used for volcanic ash detection, for VA model evaluation and data assimilation and for the improvement of satellite retrievals. He also mentioned about WMO-CIMO (Commission for Instruments and Methods of Observations) Management Group plans in conducting a feasibility study

about an inter-comparison of instruments for the detection of aerosols and volcanic ash. VAACs, VOs (Volcano Observatory), and the remote sensing research community are encouraged to form collaborative links for training and interpretation of events. The volcanic ash community is encouraged to formulate requirements (parameters, data formats, latency, possibly sites) to the GALION and GAW ground-based aerosol networks. The providers of volcanic ash detection and retrieval products should liaise with data assimilation centres to foster modelling and forecasting capabilities.

16.3. The new GAW NRT) Modelling Application SAG (Dr Hort is a member responsible for VA aspects) is open for collaboration for improvements of methods for VA prediction, including: (i) Analysis of new scientific achievements and recommendations for VA models improvements; (ii) NRT availability and use of GAW and other available observation data for VA modelling (Lidars, ceilometers, satellite, aircraft, in-situ,..); (iii) Models evaluation and inversion methods for source-term estimation; (iv) Data assimilation for volcanic plume transport modelling and prediction (VA, SO₂, ..); (v) Linkage of the satellite and modelling research communities for VA satellite retrievals use in VA modelling. Alexander also highlighted importance of WMO SDS-WAS (Sand and Dust Storm Warning Advisory System) experience for the VAACs and aviation meteorology. Collaboration of WMO GAW with VASAG, VAACs and CIMO team is suggested.

17. VAAC GUIDANCE & REGULATORY MATERIAL

17.1. The work envisaged in the furthering of the VAAC-related guidance and regulatory material has been captured in the table of VAAC BP (Best Practice) Workshop outcomes.

17.2. One of the issues that need to be addressed was to resolve existing inconsistencies in the Handbook (ICAO Doc 9766).

18. INPUTS TO METP AND NEXT STEPS

18.1. The needs for presenting operational issues to the METP WG-MOG and WG-MISD work streams on volcanic ash has been captured in the relevant sections of the report and the workshop outcomes.

18.2. The meeting discussed view and proposals of improving efficiency and effectiveness of the VAAC workshops. The possibility for the VAAC experts to meet face-to-face was considered vital in trying to make decisions on harmonization and unification of technology and procedures. VAACs felt that a longer period of internal discussion between the VAACs (e.g., two full days) would be needed to discuss operational issues in detail. This would allow the open discussion of more case studies, post event reports and related challenges.

18.3. The meeting appreciated the invitation by the VAAC Tokyo to host the next workshop (VAAC-BP/5) in May-June 2017 (exact dates to be coordinated as soon as possible).

18.4.

VAAC "Best Practice" Workshop 2016

Buenos Aires, Argentina
25-27 April 2016

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VAAC "Best Practice" Workshop 2016

Buenos Aires, Argentina
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AGENDA



Monday 25 April		Tuesday 26 April		Wednesday 27 April	
Review		Implementation		Innovation	
09:00	Registration, Workshop Opening, Intros, working practices and objectives	09:00	T+0 Confidence and Products (VWO10), MOG paper refers – <i>Darwin coord.</i>	09:00	Products in support of improved situational awareness (VWO11) – <i>London coord.</i>
10:00	Review of London 2015 VA Workshop (VWO) and Anchorage IAW/VASAG Outcomes	10:30	Break	10:00	Global Atmospheric Watch Applications <i>WMO</i>
11:30	VA Forecasting Challenges in South America – <i>Buenos Aires</i>	11:00 <i>VAACs only</i>	Discernible ash & VAG consistency (VWO03) – <i>WMO coord.</i>	10:30	Break
12:00	Lunch	12:30	Lunch	11:00	VAAC guidance & regulatory material (VWO01) – <i>WMO coord.</i>
13:00	Modelling (VWO06 and VWO07) - <i>London coord.</i>	13:30 <i>VAACs only</i>	VAAC Information Sharing (VWO04), MOG paper refers – <i>Montreal coord.</i>	11:30	Inputs to METP and next steps – <i>WMO</i>
14:00	Re-suspended Ash (VWO08) - <i>Wellington coord.</i>	15:00	Break	12:30	Workshop closure
14:30	T+24 Trial Update (VWO03), MOG VAAC reports refer – <i>Tokyo coord.</i>	15:30	VAAC products in XML <i>WMO coord.</i>		
15:00	Break	16:15	VONA and ESP BP <i>AVO Anchorage coord.</i>		
15:30	VAAC back-up arrangements (VWO05) – <i>Darwin coord.</i>	17:00	End Day 2		
16:00	Jet engine impacts (VWO12) <i>UK</i>				
17:00	End Day 1				

VOLCANIC ASH BEST PRACTICE WORKSHOP-4 OUTCOMES (VW4-O)			
No.	Description	Lead	Status
<u>VW4-O-01</u>	Clarify roles and responsibilities of the different WMO, WMO/IUGG and ICAO VA groups and meetings in a schematic way.	WMO (first draft to be presented to VASAG in Nov 16)	
<u>VW4-O-02</u>	Improve the coordination with relevant WMO groups and programmes dealing with VA driven by VAAC needs, e.g. the WMO GAW programme including SDS-WAS.	WMO (Paper to VAAC BP 2017)	
<u>VW4-O-03</u>	Modelling - All VAACs in coordination with the relevant NWP provider(s), to further investigate and report on NWP errors/performance (taking into account region specific issues e.g. tropics) relevant to volcanic ash modeling and VAAC 'Ins and Outs' Modelling tables to be reviewed, updated and shared every 2-years (next update 2018).	VAAC London (Updated tables added to VAAC BP website by end of July 2016)	
<u>VW4-O-04</u>	Re-suspended ash - Seek clarification from ICAO METP WG-MOG on whether re-suspended ash needs to be described as re-suspended on VAA and VAG. Investigate how to establish links to the WMO SDS-WAC programme.	Lead: WMO (April 2016) VAAC-BP/5; 2017	
<u>VW4-O-05</u>	T+24 Trial - Report current status of T+24 Trial to ICAO METP WG-MOG and seek advice regarding further steps (including cost-recovery aspects); consider the need to include T+24 provision in Amd 78 to Annex 3 (2018).	WMO (May 2017)	
<u>VW4-O-06</u>	VAAC back-ups – All VAACs to annually review and if necessary update (email to Raul) Doc 9766 VAAC back-up table 4.3 and VAAC contact details with back-up arrangements then tested at least annually with OPMET databanks and MWOs feedback coordinated by VAACs rather than through the medium of a State letter.	VAAC Darwin (May 2017)	
<u>VW4-O-07</u>	T+0 Confidence - Guidance material on confidence levels to be hosted by VAAC Darwin and referenced to all other VAACs websites. In the mean time continue providing T+0 confidence level. Report to MOG for eventual inclusion of a provision in Annex 3 and templates. MET info for TBO concept to be considered in future development of confidence level info.	VAAC Darwin (May 2017)	
<u>VW4-O-08</u>	ESP Database - Questionnaire on the Global Eruption Source Parameter database targeting dispersion modelers to be completed by all VAACs to inform future work on the database.	All June 2016	
<u>VW4-O-09</u>	Issues related to application, dissemination and consistency of the VONA to be referred ICAO METP WG-MOG.	ICAO (May 2017)	

VOLCANIC ASH BEST PRACTICE WORKSHOP-4 OUTCOMES (VW4-O)			
No.	Description	Lead	Status
<u>VW4-O-10</u>	XML - WMO Secretariat to advise all VAACs about the publication of the draft VAA XML schema on the WIS Wiki website. All VAACs to look at the draft XML schema and provide feedback by the determined deadline.	WMO (June 2016)	
<u>VW4-O-11</u>	Discernible Ash and VAA VAG consistency – Based on VW3-O-03, VAAC Forecast Process Best Practice 'guidance manual' to be developed with 'Discernible Ash Agreed techniques' section duplicated in Volcanic Ash Handbook.	VAAC Darwin and VAAC Tokyo, MET-P WG-MOG paper in coordination with VASAG (2017)	
<u>VW4-O-12</u>	VAAC Collaboration Tools – Development of sustainable website not possible due to limited resources. Social media based options now being investigated and trialed based on development of common requirements specification.	VAAC Montreal, VAAC BP (2017)	
<u>VW4-O-13</u>	Supplementary Products - VAACs to collaborate on the development of proposals for future 'supplementary' volcanic ash charts including, T+0 VA 'evidence' products, VA contamination level advisory products based on quantitative ash mass column loading thresholds and consideration of evolving safety management system considerations.	VAAC London, VASAG paper (late November 2016) and MET-P WG-MISD 2017 papers.	
<u>VW4-O-14</u>	Encounter Database – All workshop participants to share any ideas on how to improve occurrence reporting with carsten.christmann@dlr.de .		
<u>VW4-O-15</u>	Jet engine volcanic ash damage impacts – Common understanding that jet engine damage impacts are a function of ash mass dosage and that Doc 9691chapter 4, list 4.2 should now be considered for updating.	ICAO in consultation with ICCAIA. METP WG-MOG paper (2017).	
<u>VW4-O-16</u>	Volcanic hazard monitoring and observing capabilities Volcanic ash AIREPS, in-situ, remote sensing and volcano monitoring information availability and dissemination processes need to be enhanced and better coordinated with associated guidance including operational application best practice updated/developed. (IAVWOPSG ref 7/23, 8/3, 8/21, 8/22) – METP WG-MOG paper	WMO. Routine VASAG updates submitted to MET-P WG-MOG meetings.	

Update on 2015 VAAC BP Workshop (London) Outcomes			
No.	Description	Lead	Status
<u>VW3-O-01</u>	Volcanic ash AIREPS, in-situ, remote sensing and volcano monitoring information availability and dissemination processes need to be enhanced and better coordinated with associated guidance including operational application best practice updated/developed. (IAVWOPSG ref 7/23, 8/3, 8/21, 8/22) – METP WG-MOG paper	WMO	<i>Discussed at METP WG-MOG and agreed to provide routine updates to MET-P WG-MOG meetings as new VW4-O-16.</i> Lead: IUGG/WMO VASAG
<u>VW3-O-02</u>	Reaffirmation that VAA/VAG updates to be driven by availability of information/evidence not reflected in the current advisory (including no VA expected assessments) and not just by routine 6-hourly update cycle, Annex 3, Para 3.5.1 d) refers.		<i>Closed as agreed</i>
<u>VW3-O-03</u>	All VAACs to work collaboratively towards the development (to include seeking and sharing of user feedback) of common/consistent VAG presentation and production content (including T+24 trial) based primarily on 'agreed discernible ash techniques' (including consideration of VA tops and bases) and use of approved annotation styles, terminology and formats and message issuance targets. (IAVWOPSG ref 8/18, 8/19) – METP WG-MOG paper	VAAC London	<i>Discussed further at VAAC BP(2016) and now carried forward as VW4-O-11.</i> Lead: VAAC Darwin/Tokyo
<u>VW3-O-04</u>	Coordinated development of mechanisms (common website, chat room, exchange of process documentation BP and VAAC Ops subscription to volcanicclouds@yahoogroups.com) for improved pull-through and sharing of volcanic ash science and information into operations. (IAVWOPSG ref 7/22, 8/7) – METP WG-MOG paper	VAAC Montreal	<i>Paper submitted to METP WG-MOG(2016). New action agreed as VW4-O-12.</i> Lead: VAAC Montreal
<u>VW3-O-05</u>	All VAACs to review and update (email to Raul) Doc 9766 VAAC back-up table 4.3 and to then test back-up arrangements at least annually with OPMET databanks and MWOs feedback coordinated by VAACs rather than through the medium of a State letter. METP WG-MOG paper	VAAC Darwin	<i>Some updates still outstanding. New action agreed as VW4-O-06.</i> Lead: VAAC Darwin
<u>VW3-O-06</u>	VAAC 'Ins and Outs' Modelling tables (link to be added) to be reviewed, updated and shared every 2-years. – METP WG-MOG paper	VAAC London	<i>Tables updated and presented at VAAC</i>

Update on 2015 VAAC BP Workshop (London) Outcomes			
No.	Description	Lead	Status
			<i>BP4 (2016). New action agreed as VW4-O-03. Lead: VAAC London</i>
<u>VW3-O-07</u>	All VAACs in coordination with the relevant NWP provider(s), to further investigate and report on NWP errors/performance (taking into account region specific issues e.g. tropics) relevant to volcanic ash modelling. – <i>METP WG-MOG paper</i>	<i>VAAC Washington</i>	<i>Update presented at VAAC BP4 (2016). New action agreed as VW4-O-03. Lead: VAAC London</i>
<u>VW3-O-08</u>	All VAACs to review and share their processes, requirements and science for depicting re-suspended ash on VAA/VAG. – <i>METP WG-MOG paper</i>	<i>VAAC Wellington</i>	<i>Update presented at VAAC BP4 (2016) and discussed further at METP WG-MOG. New action agreed as VW4-O-04. Lead: VAAC Wellington</i>
<u>VW3-O-09</u>	Agreement that further research is required to better define potential SO ₂ service development requirements to inform resource requirements and pull -through of existing research-based SO ₂ monitoring and prediction capabilities into any new services to aviation. (IAVWOPSG ref 7/34).		<i>Awaiting direction from METP following submission of VASAG paper submitted to METP WG-MISD (2016).</i>
<u>VW3-O-10</u>	VAACs to collaborate on development of a T+0 volcanic ash ‘confidence’ graphical product proposal, based on the Best Practice ‘Evidence Checklist’ to underpin a High or Low confidence assessment. (IAVWOPSG ref 7/19, 7/20, 8/19) – <i>METP WG-MISD paper</i>	<i>VAAC Darwin</i>	<i>Discussed further at VAAC BP4 (2016). New action agreed as VW4-O-13. Lead: VAAC London</i>
<u>VW3-O-11</u>	VAACs to collaborate on the development of a proposal for future ‘supplementary’ VA contamination level advisory products based on quantitative ash mass column	<i>VAAC London</i>	<i>Discussed further at VAAC BP4 (2016).</i>

Update on 2015 VAAC BP Workshop (London) Outcomes			
No.	Description	Lead	Status
	loading thresholds. (IAVWOPSG ref 8/16) - IUGG/WMO VASAG paper (October) followed by paper to METP WG-MISD (2017)		New action agreed as VW4-O-13. Lead: VAAC London
<u>VW3-O-12</u>	Common understanding that jet engine damage impacts are a function of ash mass dosage and that Doc 9691 chapter 4, list 4.2 should now be considered for updating. (IAVWOPSG ref 8/26) – METP WG-MOG paper (2016)	ICAO	Discussed further at VAAC BP4 (2016). Outcome carried forward as VW4-O-15. Lead: ICAO
<u>VW3-O-13</u>	All workshop participants to share any ideas of how to improve occurrence reporting with carsten.christmann@dlr.de e.g. a central ash encounter reporting system like the one presented by DLR at the workshop.		Discussed further at VAAC BP4 (2016). Outcome carried forward as VW4-O-14. Lead: ICAO
<u>VW3-O-14</u>	'Themed' VAAC BP Workshops to continue to be held every 12 months, hosted by a VAAC State (Proposals for Buenos Aires in May/June 2016 and Tokyo in 2017), in close coordination with the relevant 5-day MET-P volcanic ash related meetings.	WMO	Closed. Agreed with relevant groups but see also new VW4-O-01.