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WORKING PAPER

INTERNATIONAL VOLCANIC ASH TASK FORCE (IVATF)

FIRST TASK FORCE

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Agenda Item 6: Improvement of ash detection/avoidance systems (Science sub-group)
6.1: Ways and means to improve ground ash detection systems
6.2: Ways and means to improve airborne ash detection/avoidance systems
6.3: Ways and means to improve space-based ash detection systems

GROUND-BASED, AIRBORNE AND SPACE-BASED ASH DETECTION/AVOIDANCE SYSTEMS

(Presented by the Secretariat)

SUMMARY

This paper relates to the development, over the years, of ground-based, airborne and space-based ash detection systems. It proposes that the task force identify technologies and recommend systems requirements to support the IAVW.

1. INTRODUCTION

1.1 The establishment of the International Airways Volcano Watch (IAVW) faced many challenges, of technical and procedural nature, which have been resolved through the cooperation of States and international organizations. In this regard, the designation of the nine volcanic ash advisory centres (VAACs), in cooperation with the World Meteorological Organization (WMO), was an excellent example of such challenges which required cooperation of all the stakeholders.

1.2 The task force (TF) will note that, according to the *Working Arrangements between the International Civil Aviation Organization and the World Meteorological* Organization (Doc 7475), it is the responsibility of ICAO to define the requirements concerning the International Airways Volcano Watch (IAVW) and it is WMO's role to define ways and means to comply with such requirements. To this end, five workshops have been organized under the auspices of WMO, in close coordination with ICAO, to deal with the scientific issues related to volcanic ash (VA).

1.3 The TF will be pleased to note that under this framework, the science behind the IAVW has progressed, over the years, as far as the ground, airborne and space-based detection systems of VA are concerned.

1.4 Since the IAVW should ensure global uninterrupted, 24-hour monitoring of VA, it may be agreed that the only feasible way of achieving this is through automated detection systems, which may be ground-based, airborne or space-based; clearly, monitoring based on visual human observations has only a limited value and cannot be used for volcanoes located in remote or oceanic areas.

1.5 Based on the unprecedented impact of the Eyjafjallajökull eruption on international air navigation, the TF may wish to concur that there is a need to urgently accelerate research on ash detection systems with emphasis on those having a global coverage.

1.6 Therefore, this paper proposes action for the science sub-group to enhance and improve the IAVW as far as the ash detection systems based on existing and new technologies are concerned.

2. IMPROVEMENT OF GROUND-BASED ASH DETECTION SYSTEMS

2.1 With regard to the ground-based ash detection systems, the TF will be aware that four types of systems can be used:

a) Doppler radar;

b) infrasound networks;

c) lidar; and

d) lightening location network.

2.2 It may be noted that the use of ground portable Doppler radar has proved to be useful for VA confirming the presence of VA in the atmosphere (in all meteorological conditions), cloud height estimation, eruption mass rate and fall out characteristics, some of these parameters being of crucial importance in the initialization of the dispersion models used by VAACs. In this regard a portable Doppler radar (C-Band, 100-km range) was successfully deployed during a recent eruption in Alaska. Not only did it provide warning information to area control centres (ACCs) due to the rapid detection of explosive volcanic eruption, the system was also able to observe the developing eruption columns (which can reach 20 km of altitude) within minutes from onset. It turned out to be very useful for monitoring volcanic cloud height with high temporal resolution especially in the early stages of the eruption when larger particles were present in the column. At the recent 5th WMO International Workshop (2010), it was concluded that radar data was underutilized in VA cloud remote sensing.

2.3 The TF will note that the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO) International Monitoring system infrasound network remains a valuable tool to detect an explosive eruption. In this regard, the use of such technology has been pursued by the International Airways Volcano Watch Operations Group (IAVWOPSG) in order to improve early detection of volcanic eruptions. Conjoint studies between CTBTO and VAAC Toulouse and the Acoustic Surveillance for Hazardous Eruptions (ASHE) Project involving VAAC Montréal and Washington have shown encouraging results, at regional and local scales, to detect the onset, duration and in most cases to estimate

the intensity of large volcanic eruptions. The fundamental drawback of the CTBTO network has been its timeliness; as the basic function of the network is to monitor nuclear explosions, information is not released immediately to the stakeholders of the IAVW.

2.4 With regard to the light detection and ranging (lidar) VA, the systems are able to sample VA plumes locally to a distance up to 10 km. In spite of its limited spatial coverage, lidar systems are useful since they can confirm the existence of VA locally and contribute to early warning.

2.5 The TF may also wish to note that the worldwide lightning location network (WWLLN) has been used to detect VA; this network, together with other monitoring information, could provide corroborative data to aid in rapid detection of explosive eruptions globally.

3. IMPROVEMENT OF AIRBORNE ASH DETECTION/ AVOIDANCE SYSTEMS

3.1 The TF will be aware, that, except for the case of an aircraft encountering the ascending VA column immediately after the eruption, airborne weather radars will not be able to detect VA; the larger particles do not remain in the atmosphere for long periods of time. It should also be emphasized that VA clouds do not produce return on the airborne weather radar. Once in the VA cloud, depending on the time of exposure and density of the cloud, the crew will observe unusual effects like static electric discharges, fine particles of ash in the cabin, the smell of sulphur, etc, which will indicate that the aircraft has encountered a VA cloud. In view of these considerations, the research on “forward looking” systems as a way to assist pilots to avoid, or safely fly around, ash clouds has always been the solution envisaged by the IAVWOPSG; however, due to substantial financial resources needed to develop such a system, it has not seen the light of day yet and, therefore, currently there are no operational airborne VA detection or avoidance systems. However, as a result of the Eyjafjallajökull eruption, at least one airline is testing infra-red technology for VA detection up to 60 miles ahead of the aircraft.

4. IMPROVEMENT OF SPACE-BASED ASH DETECTION SYSTEMS

4.1 The TF will be aware, that the space-based VA detection systems have been the backbone of the IAVW since its establishment, providing valuable information to meteorological watch offices (MWOs), to ACCs, NOTAM Offices, airlines and users. Within the IAVW, a variety of space-based (satellite) systems has been used operationally to detect VA. The use of satellite systems has been the main tool for remote monitoring in spite of their known weaknesses, i.e. the lack of VA optimization; difficulties in detecting initial eruption due to meteorological conditions etc. In satellite systems, information has been obtained from two types of operational satellites, i.e. polar-orbiting and geostationary satellites.

4.2 The group will note an update on progress concerning these systems which was provided at the 5th WMO International Workshop on VA (March 2010). In this regard the workshop’s main findings in the area of space-based ash detection systems were as follows:

a) more frequent and higher resolution satellite data is needed, with the European Meteosat Second Generation (MSG) being the best source of data in particular for Europe and Africa. Analysis of geostationary data stream shows that the Pacific Ring of Fire being relatively poorly served. The advent of Goes-R will address the needs

of the Americas; however, that is not expected until 2015 and will not assist all VAACs. Polar orbiting multi-spectral data is becoming increasingly sophisticated and available;

b) recent work in Europe and the United States has shown potential for improved volcanic cloud detection using multi-spectral data and using improved algorithms for sensing sulphur dioxide (and other volcanic gases), VA and mixed clouds. Particular improvements have been achieved in volcanic clouds height assignment. Within five years, VAACs will have access to a new level of best practice techniques;

c) the universal application of these techniques, some of the improved algorithms are designed to work with existing polar orbiting and data stream, will assist in addressing specific issues related to ash content of high altitude clouds and for reducing water/vapour effects on ash detection; and

d) the improvements expected for the next decade in satellite detection will require training of VAAC staff and users and will offer a significant improvement in aviation safety.

4.3 The TF may wish to note that the report of the WMO 5th International Workshop on VA together with previous works hops are available at the IAVWOPSG website under Seminars/Workshops, at http://www2.icao.int/en/anb/met-aim/met/iavwopsg/.

5. CONCLUSION

5.1 The group may wish to agree that, in spite of the progress made over the last few years, there is still a lot work to be done before the new techniques can be made available in an operational environment. In this regard the TF is invited to make proposals for the determination of ways and means to improve ground-based ash detection, airborne ash detection/avoidance and space-based detection systems and to continue or accelerate research to address unresolved IAVW issues. The TF, may wish to agree that emphasis should be placed on the space-based ash detection systems in view of its global coverage and universal application. The TF is also invited to agree that technologies be identified and systems requirements be formulated for ground-based ash detection, and airborne ash detection/avoidance systems to ensure that full advantage is taken of such technologies. Therefore, the TF is invited to formulate the following action agreed:

Action agreed 1/... — Improvements to VA detection/ avoidance systems

That, the Science sub-group be invited to:

a) identify technologies and recommend systems requirements for ground-based ash detection, airborne ash detection/avoidance and space-based detection systems, and

b) present a progress report at the IVATF/2 Meeting.

6. ACTION BY THE IVATF

6.1 The IVATF is invited to:

a) note the information in this working paper; and

b) endorse the draft “Action agreed” contained therein.

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