Volcanic Ash and its danger to international civil aviation

The earthquake in the Indian Ocean and the resulting tsunami that took place on 26 December 2004 reminded all of us that the Earth is not always stable and firm and that the forces released by its movements are of a magnitude that are difficult to imagine.

One of the consequences of this tragedy is that the international community is considering the installation of an early warning system in the Indian Ocean. An early warning system will enable the development of tried and tested contingency plans associated with it. Volcanic eruptions are other examples of the instability of our planet. On the surface of the earth, the size of the geographical area affected by a volcanic eruption is normally much less than that affected by the tsunami in December, but an erupting volcano produces ash that is pushed high up in the atmosphere and spread with the upper winds and its effects can be far reaching.

On 24 June 1982, a British Airways Boeing 747 lost power on all four engines while flying at 11300 m (37000 ft) from Kuala Lumpur, Malaysia to Perth, Australia. During the ensuing sixteen minutes, the aircraft descended without power from 11300 m to 3650 m (37000 ft to 12000 ft), at which point the pilot was able to restart three of the engines and make a successful emergency landing at Jakarta, Indonesia. The subsequent investigation of the incident showed that the aircraft had passed through a volcanic ash cloud and that penetration of ash particles into the engines had caused them to fail. The need to establish the capability of predicting the presence of ash particles in the atmosphere and redirect flights so as to circumnavigate 'contaminated' airspaces became evident.

Initial eruption of Grimsvotn on 1 November 2004

Volcanic Ash Forecasting System
A system called the International Airways Volcano Watch (IAVW) has been established to meet the requirements of civil aviation. The role of the IAVW is to keep aircraft in flight and volcanic ash in the atmosphere separated.

Nothing can be done to prevent volcanic ash extruding into the atmosphere and being carried by the upper winds across international air routes; however, when this happens, the aviation community has the responsibility to ensure, as far as possible,
· that the ash cloud movements are predicted and monitored,
· that pilots concerned are advised, and
· that aircraft are routed safely around the ash clouds.

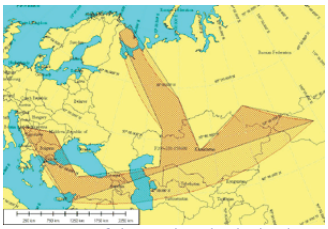
To carry out these functions, nine Volcanic Ash Advisory Centres (VAAC) are continuously watching the volcanoes, using several different sources, among them volcanic observatories and meteorological satellites. When necessary, the VAACs will perform the task of predicting, monitoring and informing. When an eruption occurs they issue special forecasts, Volcanic Ash Advisories (VAA), based on atmospheric computer models. The VAAs are used for planning by Air Traffic Management (ATM) and airlines and for the issuance of Volcanic Ash SIGMETs.

Eruption in Iceland
Iceland's most famous volcano, Katla, in the Myrdalsjokull glacier, has erupted on average every 80 years. Sixteen eruptions have been recorded since the settlement of Iceland and the last one was in 1918. Katla's eruptions usually have very serious consequences as the glacier above the volcanic vent melts and the melt-water collects under the ice cap until it makes its way out under the edge in a violent flood. Huge amounts of ice and sand are carried along by the floodwater, and anything in the path of the flood tide is destroyed. In addition, the eruptions tend to last more than two weeks.
Another of the major hazards of a Katla explosive eruption is the atmospheric dispersal of ash and aerosol across Europe, with subsequent environmental and human consequences. A future major Katla explosive eruption would be a notable volcanic event in the North Atlantic with subsequent disruption of air traffic. New studies on Katla volcano are being initiated to better understand the development of a future large eruption and the pan-European environmental consequences.

An article written by Thomas Grindle and Frank Buchanan jr, which was published in the ICAO Journal (Nr 2, 2002), provided a clear account of the effects that ash clouds could have on aircraft operations. A fully equipped NASA research aircraft flew into an unreported ash cloud in February 2000. Because the aircraft research equipment was operating, the scientists were able to detect that they were in an ash cloud. It is very difficult to see the clouds, especially when the particles are very small. This incident led the North Atlantic Systems Planning Group to initiate a study of the effects that a volcanic eruption could have on the air traffic operating in the NAT Region and to develop an Air Traffic Management contingency plan. To develop a contingency plan, a study, which consisted in running together the ash cloud simulation and the air traffic simulation to estimate the impact on air traffic by a volcanic eruption, was carried out.

It was noted that up to 262 flights per day could be directly affected by a volcanic eruption or 71% of the total number of aircraft flying in Reykjavik control area. Of those, up to 99 can be airborne during the first 30 minutes of the eruption. Scottish area control centre has most of the airborne flights that are affected in their area during the first minutes but they are quickly shifted to Reykjavik control area if no changes are made. The average increase due to rerouting is 24-30 NM. The change in the number of flights, with and without an eruption, in separate control areas was analysed and revealed that there is a shift of traffic from the Reykjavik control area into the Shanwick area. Other areas have very similar traffic numbers for both scenarios. The rerouting process showed that additional aircraft would be affected, not directly by the eruption, but by aircraft being rerouted. Up to 44 aircraft could be affected in this way. In addition to this the total number of aircraft affected, in one way or the other, can be as high as 82%.

The effects of a volcanic eruption
Iceland has well developed ways and means of monitoring and forecasting volcanic activities, and it was no surprise when an eruption started at Grimsvotn on 1 November 2004. The ash plume rapidly reached FL 400. The upper part of the plume entered the jet stream, which transported the ash cloud as far as the Black Sea and Turkey in a few days. In the last stage of the eruption, the ash cloud covered large parts of the European Region airspace. Figure 2 below is illustrative.



Extent of the predicted ash cloud using a combination of earth projection models

As a result, at least one airline cancelled a flight from New York to Moscow and several airlines were re-routed or cancelled. A spokesman for IATA said, "the financial damage for the airlines was considerable". Large tracks of the airspace were closed as the huge ash cloud extended from Iceland to the Black Sea.

ICAO EUR/NAT Volcanic Ash Working Group (VAWG)
The ash cloud from Grimsvotn affected large areas of the EUR Region's airspace that had never previously been affected in such a way since the IAVW procedures were introduced. That meant that certain parts of IAVW procedures concerning distribution of VAAs and SIGMETs to ATM and the airlines did not work as planned. In addition, although an ATM contingency plan exists for the NAT Region, none does for the EUR Region.

Considering the very serious implications that such an event could have on the air space management, in particular over the areas with very high traffic intensity like the NAT-tracks and the Western part of the EUR Region, the relevant experiences had to be collected and analyzed with the goal to find out lessons to be learned and how to further improve the systems.

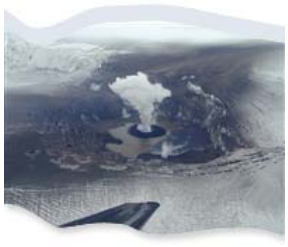
The implications were both safety related and financial.
An ad hoc EUR/NAT Volcanic Ash Working Group (VAWG) was therefore established with the task of collecting and analyzing all relevant lessons to be learned, of identifying areas for further action and the bodies to deal with them at the regional and global level.
The ad hoc EUR/NAT VAWG, including ATM and MET experts, together with airline representatives, met once at the ICAO EUR/NAT Office in Paris in January 2005. During this meeting several important experiences were reported and discussed. A list of items was identified for follow up actions on both the global and regional levels in order to further improve the VAAs and the implementation of regional IAVW procedures. The need to develop ATM contingency procedures for the EUR Region was identified to be of high priority.

Future Work
Several items from the EUR/NAT VAWG were of a global nature and would be presented to the North Atlantic Systems Planning Group (NAT SPG) and the European Air Navigation Planning Group (EANPG) who would in turn address them to the International Airways Volcano Watch Operations Group (IAVWOPSG), while items related to implementation deficiencies at a regional level would be addressed directly by the ICAO EUR/NAT Office.
As a first step, a special Task Force was established under the auspices of ICAO to develop ATM volcanic ash contingency procedures for the EUR Region. This work would highly benefit from the experience in the NAT Region, where such procedures had already been implemented for several years.

Final conclusion

It can be concluded that a volcanic eruption in Iceland can have great effect on air travel in both the NAT and EUR Regions. The area affected by a volcanic eruption can be quite large within a short period of time. Further, there can be a significant number of aircraft airborne when the eruption starts. The vast majority of the aircraft can be affected either directly or indirectly under certain weather conditions. The ash cloud spreads rapidly and can cover large portions of airspace with the knock on safety and economic effects on international civil aviation.

Although an effective early warning system is in place, the EUR Region lacks an effective and robust contingency plan that would take account of safety of flight as well as the economic penalties associated with airspace closure.



The end of the eruption

Accordingly, the EUR/NAT Office of ICAO established a Task Force to develop an ATM contingency plan. The Task Force is composed of Iceland, Italy, Norway, Russian Federation, Eurocontrol, IATA and VAACs. The contingency plan, which should take due account of the economic fall out of a major volcanic eruption, would address short term and long term actions to be taken. The contingency plan should be delivered to the European Air Navigation Planning Group at their next meeting in November 2005.

When the contingency plan is developed, it will be thoroughly tested and validated. At that time, the EUR and NAT Regions will have both an effective early warning system and a robust contingency plan to mitigate to the extent possible the fall out from a major volcanic eruption.