



Test the effects of ash on jet engines

*To judge the safety of flying during an eruption, the airline industry cannot just rely on advances in volcanic monitoring and prediction, says **Matthew Watson**.*

Next week marks five years since the eruption of the Icelandic volcano Eyjafjallajökull that halted air traffic over Europe. For six days flights were grounded as politicians and the public wrestled with ideas of risk management and scientific uncertainty. Good decisions were made at the time, but in the immediate aftermath, governments and airlines promised that they would learn the lessons of a shutdown that cost the global economy an estimated US\$5 billion. So would things be different if the same eruption happened tomorrow? Yes and no.

We were unlucky in 2010. The magma produced by the volcano was rich in silica, making the lava very viscous, and it emerged amid abundant glacial melt water. As a result, the ash particles were unusually fine, and travelled far into the heart of Europe on (very inconvenient) stable northerly winds.

There have been two eruptions in Iceland since 2010: Grímsvötn in 2011 and Bárðarbunga in 2014–15. Neither had the same impact, partly because the meteorological and geological conditions were more benign. But partly also because our ability to monitor ash clouds, and to predict how they disperse, has improved. These improvements have fed into better management of air space, and ultimately helped us to keep more planes flying.

The biggest policy change since 2010 is a shift from a decision-making process that responded simply to the presence of any ash, to one based on a safe threshold. Aircraft can now fly as long as the ash concentration does not exceed 0.2 milligrams per cubic metre.

This safety limit demands more accurate satellite measurements of atmospheric ash than were available in 2010. Frustratingly for those of us in the field, the knowledge existed to make these measurements five years ago, but was not used. In fact, the basic satellite algorithm to detect ash levels in 2010 was already 20 years old. It takes time to translate research findings into applications, but it is a salutary lesson that it took a crisis to provoke the political effort to upgrade to using more-recent research.

Other rapid advances have been made since 2010 which, coupled with the (better late than never) uptake of existing algorithms, have led to a step change in our ability to remotely monitor eruptions and to track the concentration and height of ash.

Dispersion models have improved. One example is PlumeRise, a fluid dynamical model that corrects for the interaction of wind with the eruption column. This helps researchers to calculate more accurately the intensity of the eruption, which improves model predictions. Models used during the 2010 crisis did not account for the bending of the column in high

wind, and potentially underestimated the amount of material injected into the atmosphere. The online version of this model is now used by volcanic ash advisory centres around the world — directly as a result of the Eyjafjallajökull event.

There has also been major investment in hardware. An array of state-of-the-art ground-based sensors has been deployed in Iceland to measure both volcanic ash and gases. Here in the United Kingdom, the government has invested in a Lidar network to monitor ash from the ground, and a second aircraft specifically to check levels from the skies.

Decision-makers are better informed of the hazard and possible responses than they were in 2010. For example, the risk that volcanic ash poses to airspace and infrastructure is now captured in the national risk register, which lays down scenario plans for different types and

scales of volcanic activity. And the eruptions of Grímsvötn and Bárðarbunga provided an opportunity to test and improve these responses.

The Civil Aviation Authority (CAA) has developed new rules for flying in ash. UK airspace is now divided into three areas of density: low, medium and high. All aircraft may fly in low-density areas but airlines are required to set out how they intend to fly their fleet safely through medium- and high-density areas and have these safety cases approved by the CAA. The CAA states that many safety cases are already in place for medium-density areas.

Does that all mean that airspace will never again be shut, as it was in 2010? Probably, but with a couple of important caveats. First, some events will have an impact no matter how well managed. A very large, ash-bearing eruption

would still halt air traffic.

Second, despite being able to monitor, measure and predict the concentrations of ash more adroitly, considerable uncertainties remain. The largest of these is how tolerant jet engines are to ash, particularly the newer and hotter engines.

Very few tests have been conducted to see how engines cope with ash. Such experiments are expensive and complex to run, especially on whole engines (rather than just on components). Yet, without a clearer idea of that tolerance, sharp delineations of the acceptable areas to fly in, such as those made by the CAA, are unrealistic. Some experiments are planned. Until then, airlines are likely to struggle to make a convincing safety case to fly in medium or high densities of ash.

Without that effort from the industry, a lot of the scientific progress made will be hard to use during the next ash-cloud crisis. ■

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