ANALYSIS OF PROPAGATION AND THE IMPACT OF HYPOTHETICAL VOLCANIC CLOUD ON AIR TRANSPORT OPERATIONS IN POLAND

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1. Introduction

The influence of volcanic cloud propagation on air transport operations in Poland is predicted and analysed by simulating a hypothetic volcanic eruption. The analysis is based on ICAO procedures and historical information coming from VAAC, Polish weather services and Air Traffic Control. Worldwide aircraft accidents and incidents caused by the previous volcano eruptions are reviewed to assess the potential impact of volcanic clouds on jet engine operation and airspace availability in Poland and Central Europe.

2. Objectives

- Analysis of propagation and the impact of hypothetical volcanic cloud on air transport operations in Poland;
- How volcanic ash cloud influences air transportation operations;
- VA effects on modern jet aircraft in operation and on the ground.

3. Description of area

A hypothetical eruption of the Eyjafjallajökull volcano is analyzed to estimate the average time at which volcanic ash cloud penetrate the Polish airspace. Weather conditions are assumed in accordance with the messages provided by the national service (IMGW) for pilots and flight crews in Poland. The propagation calculations are made on the basis of the assumed hypothetical data of the eruption. For the given explosiveness index of volcano, you can take an average flow speed of eruption column into the atmosphere, as well as the height of the column of ash. On this basis, we estimate the time in which volcanic clouds rise up to the height where jet streams are present. Jet streams are the main carrier of volcanic ash, which are able to transport the cloud a few thousand kilometers.

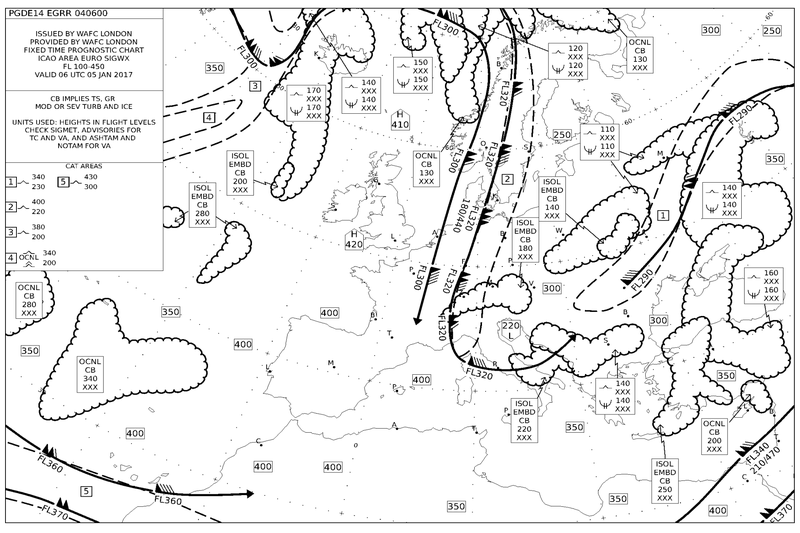

Fig 1. Significant weather chart 05.01.2017, 06:00 UTC

Significant weather charts show the presence and speed of jet streams on high altitudes, so it can be used for calculation of volcanic ash propagation.

4. Environment for analysis preparation

Selected conditions of hypothetic volcano eruption:

- volcano: Eyjafjallajökull
- localization: southern Iceland
- date and time of eruption: 4 January, 4:00 PM UTC
- index of volcano explosivity: 6
- height of the eruption column: > 25 km
- assumed vertical speed of rising up volcanic ash: 400 kt = 740 km/h

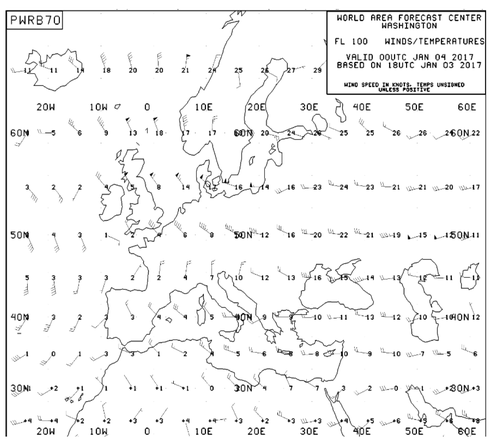

Fig 2. Weather chart winds and temperatures at FL 100, 04.01.2017, 00:00 UTC

5. Data and analysis

Given the distribution of the jet stream in the vicinity of Iceland you estimate the time the ash reaches Polish territory. The typical direction and the speed of wind at 10 km altitude is assumed. It turns out that volcanic cloud reaches Poland about 19 hours after the eruption. Appropriate decisions for Polish airspace must be taken by ACC before the cloud arrival.

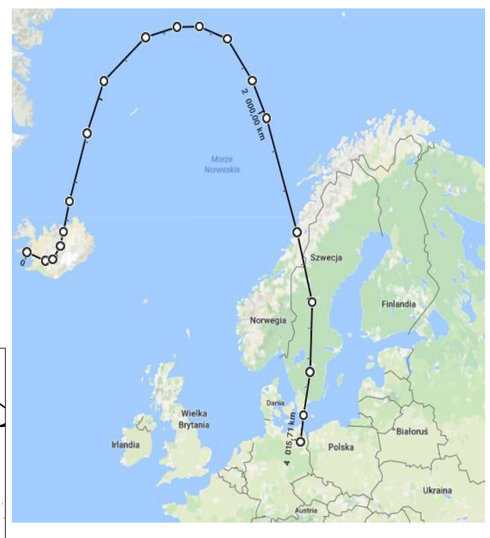

Fig 4. Trajectory of volcanic ash cloud coming from hypothetic Eyjafjallajökull eruption, 04.01.2017

- Distance of cloud glide: 4016 km.
- Vertical speed of ash column: 740 km/h
- Altitude of jet stream: FL300 = 9144 km
- Time of rising up ash column:

$$t = \frac{9{,}144 * 60}{740} = 44\ [s]$$

- Average speed of jet stream:

$$v\ avg = \frac{v1+v2+v3}{3} = \text{[km/h]}$$

$$v\ avg = \frac{259{,}3+166{,}8+203{,}7}{3} = 209{,}94\ \text{[km/h]}$$

- Average time to reach Poland:

$$t = \frac{4015{,}71}{209{,}94} = 19h\ 08min$$

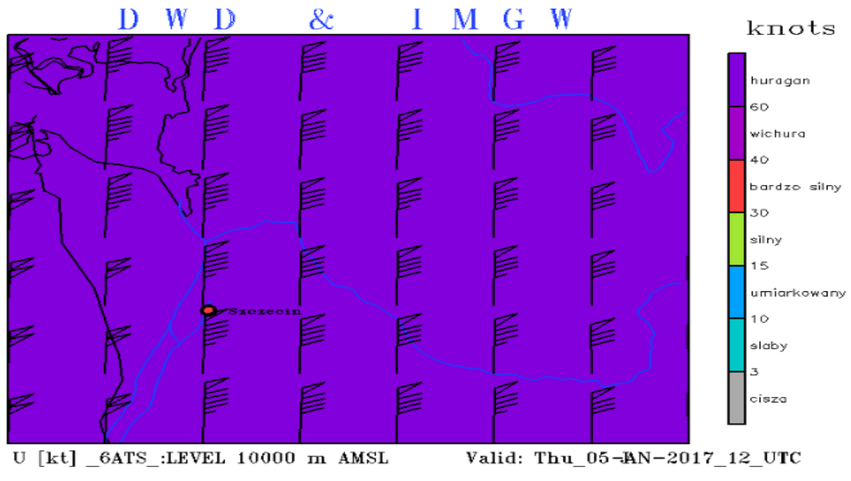

Fig 5. Weather chart winds on 10000m, 05.01 Szczecin, 12:00 UTC

6. Impact of VA on the aircraft

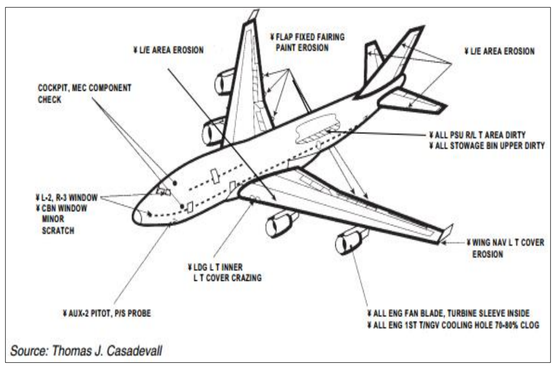

Fig 6. Impact of VA on the aircraft

Class 0
- acid smell in cabin
- mist in the air
- electrical discharges
- volcanic ash detected
- no damages

Class 1
- dust in the cabin
- accumulated volcanic ash on the surfaces of the aircraft
- fluctuations of the EGT temperature

Class 2
- choking dust in the cabin
- dirty air conditioning system, necessity of using oxygen mask
- erosion of surfaces, engines inlets, turbines and compressors blades
- scratches on windows
- volcanic material accumulated inside engines

Class 3
- engine vibrations
- pressure ports totally blocked
- dust detected in fluids: oil, hydraulic fluid
- damages of air data computers and electronic systems
- major engine components damaged

Class 4
- temporary engine flame out

Class 5
- all engine components damaged, plane crashed

7. Summary

Recommendations are given to pilots and local aviation authorities, including small general aviation entities. Currently, many aviation training centers, aero clubs and other organizations lack implemented procedures in the event of the presence of volcanic clouds.

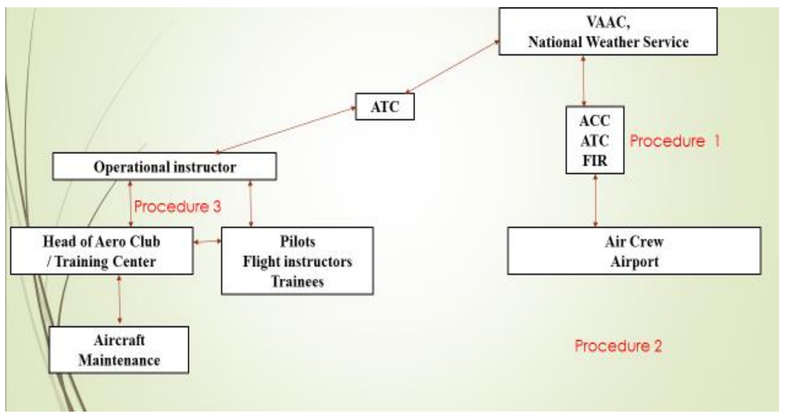

Fig 7. Volcanic clouds advisory procedures for general aviation

Procedure 3 for Aero Club / Training Center:

- Continuous monitoring of weather information, messages and reports on volcanic activity.
- Limitation of air operations in the event of volcanic cloud presence in the region.
- Visual inspection od the aircraft after flight covering leading edges of the wings, windows, pressure ports, air intakes and air filters.
- Shortening inspection intervals.
- Additional inspections to check the impact of volcanic ash on individual components.
- Aircraft on Ground for investigation and repair in case of damage from volcanic ash.

References

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