Analysis of Impacts an Eruption of Volcano Stromboli could have on European Air Traffic

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Structure

- Introduction and research motivation
- Background
- Methodology and simulation
- Results of simulation scenarios
- Outlook
Introduction and research motivation

- 2010 events and the European policy concerning volcanic ash
- Current regulatory situation in Europe
- Safety risk assessment (SRA)
Introduction and research motivation

- 2010 events and the European policy concerning volcanic ash
- Current regulatory situation in Europe
- Safety risk assessment (SRA)

<table>
<thead>
<tr>
<th>Types of SRA in Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L</strong></td>
</tr>
<tr>
<td>Allows operations in areas forecasted to be contaminated with low ash concentration (&lt; 2 mg/m³)</td>
</tr>
<tr>
<td><strong>L/M</strong></td>
</tr>
<tr>
<td>Allows operations in areas forecasted to be contaminated with low and medium ash concentration (&lt; 4 mg/m³)</td>
</tr>
<tr>
<td><strong>L/M/H</strong></td>
</tr>
<tr>
<td>Allows operations in areas forecasted to be contaminated with low, medium and high ash concentration (&gt; 4 mg/m³)</td>
</tr>
</tbody>
</table>
Introduction and research motivation

- 2010 events and the European policy concerning volcanic ash
- Current regulatory situation in Europe
- Safety risk assessment (SRA)
- Research question: "What is the difference in posed number of encounters with volcanic ash cloud when different SRA is applied?"
- Novel approach of opening restricted zones and the effect on the operations
Background

- ICAO's regular volcanic ash exercise (VOLCEX14/01) related to Stromboli volcano
- Characteristics of the volcano
- Characteristics of the eruption
  - First day plum attributes
  - Second day plum attributes
- Simulation environment
  - Fast – time simulation tool
  - Route generator (RouGe)

The simulation environment represented in AirTOp
Methodology and simulation

- Analyzed day
- Volcanic ash and air traffic data
  - The Volcanic Ash Advisory Centre (VAAC) Toulouse provides three sets of data containing forecasts of volcanic ash
  - The EUROCONTROL provides 24 hours traffic data (for research purposes only)
- Applied types of SRA

<table>
<thead>
<tr>
<th>SRA for Volcanic Ash Events</th>
<th>Number of Airlines (%)</th>
<th>Type of SRA</th>
<th>Number of Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>77.9</td>
<td>L&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L/M&lt;sup&gt;b&lt;/sup&gt;</td>
<td>62.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L/M/H&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.6</td>
</tr>
<tr>
<td>NO</td>
<td>22.1</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Methodology and simulation

- Applied airspace model
- DLR's Network Flow Environment (NFE)
- Model based on EUROCONTROL's DDR2 database and European AIS database (EAD)
- The model contains 640 individual sector volumes
Methodology and simulation

- Definition of the restricted zone
  - Military regular exercises or protection of areas with high value

- Two generic restricted zones created for the purpose of the study (restricted zone A and restricted zone B)

Restricted zones in the vicinity of volcanic ash cloud
Methodology and simulation

- Definition of airspace capacity
- Potential reduction of the volcanic ash eruption impact on the ATM
- Sample sectors A, B and C defined to measure the capacity according to the position and concentration of the volcanic ash

Airspace A, B and C selected to measure the capacity
Methodology and simulation

- Aim of the analysis and setup of the fast – time simulation scenarios
  - Seven simulation scenarios
  - Baseline scenario including 24,000 flights (due to the eruption characteristics flights before 06:00 UTC and after 18:00 UTC are omitted from investigation)

- Goal: to measure capacity in the sectors A, B and C with the assumption that there is no disruption

Flights through European airspace without volcanic ash disruption (baseline scenario)
Methodology and simulation

- Scenarios two through seven take into account the disruption posed by volcanic ash cloud
  - Sim two and three: restricted zones open and closed respectively, no SRA and number of rejected flights is 819
  - Sim four and five: application of SRA (< 2 mg/m3), restricted zones open and closed respectively and number of rejected flights is 460
  - Sim six and seven: application of SRA (< 4 mg/m3), restricted zones A and B open respectively and number of rejected flights is 187

Concentration of the volcanic ash cloud on the second day plum
Methodology and simulation

- Application of SRA and ash concentration

- Application of no SRA
- Low ash concentration
  (<2mg/m³)
- Medium ash concentration
  (<4mg/m³)
Goal: to determine baseline capacity of the airspaces (without disruption) and comparison to the capacity when volcanic ash is present in the air

- Single trajectory flight
- Volcanic ash cloud spread up to FL250
- Aircraft FL 370

Rerouted flight in contaminated L/M/H area (>4mg/m3)
Results of simulation scenarios

- Posed number and duration of encounter with volcanic ash cloud

<table>
<thead>
<tr>
<th>Type of SRA</th>
<th>Number of simulated flights</th>
<th>Number of flight with encounter</th>
</tr>
</thead>
<tbody>
<tr>
<td>No SRA</td>
<td>23,927</td>
<td>1,922</td>
</tr>
<tr>
<td>L</td>
<td>23,927</td>
<td>1,675</td>
</tr>
<tr>
<td>L/M</td>
<td>1,074</td>
<td></td>
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</tbody>
</table>
## Results of simulation scenarios

- Capacity analysis of the ATC sectors

<table>
<thead>
<tr>
<th>Type of SRA</th>
<th>Number of simulated flights</th>
<th>ATC Sector</th>
<th>Max Sector Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>No Ash</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rest. Zone closed</td>
</tr>
<tr>
<td>No SRA</td>
<td>23,927</td>
<td>A</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>23,927</td>
<td>A</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>48</td>
</tr>
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<td>48</td>
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<tr>
<td>L/M</td>
<td>23,927</td>
<td>A</td>
<td>32</td>
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<td></td>
<td></td>
<td>B</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>48</td>
</tr>
</tbody>
</table>
Results of simulation scenarios

- The undertaken simulations gave results that were not sufficient to answer all of the above defined questions
- Further investigations are required to clarify that question in detail

The re-routing of the aircraft affected by the volcanic ash cloud performed by the AirTOp’s shortest route logic

An example of the results showing the fluctuation in traffic demand
Outlook

- Preliminary results in a very complex and dynamic simulation environment
- Cancelation of flight operations and even reduction of the capacity issues on the surrounding airspaces there is still a possibility for further developments of simulation scenarios set-up
- The undertaken investigation takes into account simulated eruption of volcano Stromboli and therefore further analysis taking into account realistic explosive eruptions (especially the latest ones) are highly required for utter understanding of the effects on the European air traffic.