Analysis of Airspace Infringements in European Airspace

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My Background

2012 – Now  Research student in aviation safety at Lloyd's Register Educational Trust Transport Risk Management Centre, Centre for Transport Studies

2011 – 2012  MSc in Transport from Imperial College and UCL

2007 – 2011  Undergraduate degree in Civil Engineering from Cyprus University of Technology

Motive: Helios crash in Athens 2005

• 121 fatalities (93 adults, 22 passengers are children and teenagers)
Outline of Presentation

• Definition of Airspace Infringements (AIs)
• Studies by EUROCONTROL
• Proposed methodology
• Results
• Conclusions
What is an Airspace Infringement (AI)?

Southern Norwegian airspace

- Controlled airspace
- Uncontrolled airspace

Oslo TMA

Farris TMA
Consequences

- No problem to controllers and traffic in controlled airspace
- Delays
- Loss of separation with other traffic and high risk of a mid-air collision
European Statistics

- Frequency of incidents
- Impact on safety
- Unclassified/Not determined incidents

Safety Regulation Commission (2012)
### Studies by EUROCONTROL

<table>
<thead>
<tr>
<th></th>
<th>Part I: Safety Analysis of Airspace Infringements in Europe 2007</th>
<th>Part II: General aviation airspace infringement survey 2007</th>
<th>Part III: Case study Switzerland</th>
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</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
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<tr>
<td>Safety data</td>
<td>X</td>
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<td>GA pilot survey/ discussion</td>
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<td><strong>Methodology</strong></td>
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<td>Frequency analysis</td>
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<td>Severity analysis</td>
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<td><strong>Findings</strong></td>
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<td>Detailed factors</td>
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<tr>
<td>Insufficient information</td>
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</table>
Aims of this Presentation

Development of a robust safety analysis methodology for AIs involving GA in Europe using incident reports
Methodology

- Coding dataset
- Quality assessment of the data
- Descriptive statistics of AIs
- Identification of contributory factors
- Frequency analysis of contributory factors
- Design of severity models
- Combined model

Associations between contributory factors
Avinor safety data (2008-2012)

CASE STUDY
Quality Assessment

Diagram: Quality Assessment Metrics

- Relevance
- Accessibility
- Completeness
- Consistency

Axes:
- X-axis: %
- Y-axis: Relevance, Accessibility, Completeness, Consistency

Values:
- Quality assessment metrics range from -100 to 100.
Descriptive Statistics

- 88% incidents: Infringing aircraft
- 80% incidents: GA aircraft VFR
- 75% incidents: En-route flight phase
- 54% incidents: Airspace Class D
- 31% incidents: Airspace Class C
- 70% incidents: Pilot is involved
Phenomenon of Seasonality
Location of Incidents

- Location related to:
  - Quality of flight plan
  - Two-way radio contact

Southern 79%
Northern 21%

Bodo
Oslo
Two-way Radio Contact

Radio contact establishment

- Contact after the incident: 25%
- Contact before the incident: 15%
- No radio contact: 60%
Causal Category

Airspace Infringement - Causal category

- Pilot navigation skills: 46%
- Pilot communication skills: 21%
- Controller skills: 19%
- Equipment: 11%
- Environmental: 3%

- Quality of flight plan
- Inadequate knowledge of navigation:
  - Airspace structure
  - Airspace procedures
  - Airspace boundaries
COMBINED MODEL
### Stage I: Ranking Contributory Factors

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Contributor</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No/Poor radio contact</td>
<td>317</td>
</tr>
<tr>
<td>2</td>
<td>Use of wrong frequency</td>
<td>68</td>
</tr>
<tr>
<td>3</td>
<td>No/Poor of Flight Plan</td>
<td>58</td>
</tr>
<tr>
<td>4</td>
<td>Inadequate knowledge of airspace boundaries</td>
<td>56</td>
</tr>
<tr>
<td>5</td>
<td>Inadequate knowledge of airspace procedures</td>
<td>49</td>
</tr>
<tr>
<td>6</td>
<td>Loss of awareness</td>
<td>47</td>
</tr>
<tr>
<td>7</td>
<td>Unfamiliar airspace and/or route</td>
<td>45</td>
</tr>
</tbody>
</table>
Stage II: Severity Models

- Two models:
  - Safety effect on aircraft involved
  - Safety effect on ATM
- Binary discrete choice models
- Binary depended variable = likelihood of each category (a) of variable
  - 0 “no impact” \( \rightarrow \) ESARR class D and E
  - 1 “significant” \( \rightarrow \) ESARR class A, B and C

\[
\text{Logit} \left( P_i(a) \right) = \ln \left( \frac{P_i}{1-P_i} \right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k \tag{1}
\]

\[
P_i(a) = \frac{\exp(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k)}{1 + \exp(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k)} \tag{2}
\]
Safety Effect on Aircraft Involved

Binary logistic regression model
(Level of confidence 95%)
2008-2011 data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Odds</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.788</td>
<td>0.455</td>
<td>0.036</td>
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<tr>
<td><strong>Pilot is involved</strong></td>
<td>1.588</td>
<td><strong>4.893</strong></td>
<td>0.004</td>
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<tr>
<td>Summer period</td>
<td>0.321</td>
<td>1.379</td>
<td>0.321</td>
</tr>
<tr>
<td><strong>Location of incident (South)</strong></td>
<td>0.738</td>
<td><strong>2.092</strong></td>
<td>0.007</td>
</tr>
<tr>
<td>Inadequate knowledge of airspace procedures</td>
<td>-0.662</td>
<td>0.516</td>
<td>0.095</td>
</tr>
</tbody>
</table>
Safety Effect on ATM Service

Binary logistic regression model
(Level of confidence 95%)
2008-2011 data

<table>
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</tr>
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<tr>
<td>Intercept</td>
<td>-1.984</td>
<td>0.137</td>
<td>0</td>
</tr>
<tr>
<td>Summer period</td>
<td>0.925</td>
<td>1.572</td>
<td>0.43</td>
</tr>
<tr>
<td><strong>No/Poor flight plan</strong></td>
<td>0.925</td>
<td><strong>2.522</strong></td>
<td><strong>0.082</strong></td>
</tr>
<tr>
<td>No/Poor radio contact</td>
<td>-0.428</td>
<td>1.535</td>
<td>0.233</td>
</tr>
</tbody>
</table>
Conclusions

• Qualitative and quantitative analysis for high-quality data
• Factors related to navigation and communication skills of pilots are found in Avinor data
  • Quality of flight plan
  • Knowledge of airspace boundaries
  • Establishment of two-way radio contact
• Directly useful for Avinor
  • e.g. southern Norway, spring time
  • Pilot’s performance when they fly near to the boundary of controlled airspace using new VFR flight planning and navigation software
• Further research
  • Understand general aviation pilot’s factors by discussing with pilots, flight instructors and other stakeholders and observations

Thank you for your attention!