Simulating the Risk of Bird Strikes

Isabel C. Metz, Joost Ellerbroek, Thorsten Mühlhausen, Dirk Kügler, Jacco M. Hoekstra
Motivation

Bird Strike Risk and Mitigation Measures

3000 ft AGL

Source: FAA

Altitude distribution of bird strikes in the US between 1990 and 2015

Source: FAA

Source: usatoday.com

Source: dailymail.co.uk
Motivation

Bird Strike Risk and Mitigation Measures

3000 ft AGL

altitude distribution of bird strikes in the US between 1990 and 2015

source: FAA

source: cbsnews.com
Motivation

Role of Air Traffic Control
Concept

Bird Strike Advisory System

Increased Safety? deterministic? Decreased Capacity?

Feasibility?
Concept

3000 ft AGL

t = 0.5

t = 1.5

t = 2.5

t = 3.0

t = 3.5

Bird Strike Advisory System

Increased Safety? deterministic? Decreased Capacity?

Feasibility?

fast-time simulations
Fast-Time Simulation Environment

- air traffic simulation platform
- bird movement model
- collision model
Simulation Environment
Air Traffic Simulation Platform

BlueSky Open Air Traffic Simulator

- real- and fast-time simulator
- visualization and evaluation of
  - air traffic flows
  - ATM concepts
- modular structure
- open data & open sources
Simulation Environment

Bird Movement Model

3000 ft AGL

source: robinradar.com  source: govtech.com
Simulation Environment

Bird Movement Model: Direct Airport Environment

input
• time-stamped 2D positions
• id
• category

processing
• at least 20 positions per bird
• categories: small, medium, large, flocks
Simulation Environment

Bird Movement Model: Extended Airport

**input**
- bird reflectivity
  \[ \eta = \rho_{\text{bird}} \sigma_{\text{bird}} \left( \frac{\text{cm}^2}{\text{km}^3} \right) \]
- velocities in u and v direction

**processing**
- bird number (\( \sigma_{\text{bird}} = 11 \text{ cm}^2 \))
- constant speed (SD = 5 \( \frac{\text{m}}{\text{s}} \))
- constant direction (SD = 45°)
Simulation Environment

Collision Model: Protected Zone Aircraft

\[ S_{front} = b \times h = (b - 2 \times r_f) \times h_w + n_e \times r_e^2 \times \pi + r_f^2 \times \pi \]

- \( b \): wings
- \( h \): engines
- \( r_{f} \): fuselage

[Diagram of an aircraft with labeled parts]
Simulation Environment

Collision Model: Protected Bird

\[ r = \sqrt{n_{birds}} \times \frac{b}{2} + c \]

based on Graham 1996
Verification

Simulation Setup

336 Scenarios
Results

Bird Strike Rate: Number of bird strikes per 10,000 flights

<table>
<thead>
<tr>
<th>Air Traffic Intensity</th>
<th>Bird Strike Rate</th>
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</thead>
<tbody>
<tr>
<td>high</td>
<td>21.59</td>
</tr>
<tr>
<td>medium</td>
<td>19.48</td>
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<tr>
<td>low</td>
<td>21.78</td>
</tr>
<tr>
<td>very low</td>
<td>15.07</td>
</tr>
<tr>
<td>Eindhoven (reference)*</td>
<td>12.33</td>
</tr>
</tbody>
</table>

* average for the period from 2007 to 2016

last-minute escapes? unreported strikes?
Results

Altitude Distribution

Chart 16 > Simulating the Risk of Bird Strikes > SESAR Innovation Days 2017 > 29 November 2017

Source: FAA 2017
## Results

### Bird Strike Rate and Altitude Distribution

<table>
<thead>
<tr>
<th>Airport</th>
<th>Bird Strike Rate</th>
<th>Bird Strike Rate (theoretical)</th>
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</thead>
<tbody>
<tr>
<td>high</td>
<td>21.59</td>
<td>41.43</td>
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<tr>
<td>medium</td>
<td>19.48</td>
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<td>Eindhoven (reference)</td>
<td></td>
<td>12.33</td>
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</tbody>
</table>

![Chart showing bird strike rate by altitude](chart.png)
Results

Seasonal Distribution

![Seasonal Distribution Chart](image)
Conclusions

- simulation environment developed
  - bird movement and collision model

- promising results achieved
  - bird strike rate
  - altitude distribution
  - seasonal distribution

- next step
  - develop collision avoidance algorithm

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Monte Carlo Simulations

Bird Strike Advisory System

Increased Safety? deterministic? Decreased Capacity?

Feasibility?

Thanks! Questions?