What is the Potential of a Bird Strike Advisory System?

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ATM R&D Seminar 2019
Motivation

Bird Strike Definition

A bird strike is strictly defined as a collision between a bird and an aircraft which is in flight or on a take off or landing roll. The term is often expanded to cover other wildlife strikes - with bats or ground animals.

[Eurocontrol]
Motivation

Bird Strike Risk

3000 ft AGL

Birds are a hazard to aircraft. Do not feed birds or leave edible waste.

Quelle: FAA
Motivation

Bird Strike Risk

3000 ft AGL

2,818 ft

Quelle: FAA
Motivation

Bird Strike Risk

3000 ft AGL

how to involve ATC and pilots?

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

Source: FAA
Motivation

Involving ATC and Pilots

Wildlife Control -> ATC -> NOTAM

Sensor Data -> Advisory System

Wildlife Control <-> ATC

Chart 6 > What is the Potential of a Bird Strike Advisory System? > ATM R&D Seminar 2019 > 02 July 2019
Concept

3000 ft AGL

$t = 0.0$
$t = 1.0$
$t = 2.0$
$t = 3.0$
Concept

3000 ft AGL

$ t = 0.5 \quad t = 1.5 \quad t = 2.5 \quad t = 3.5 $
Concept

Bird Strike Advisory System

Increased Safety? deterministic? Decreased Capacity?

Feasibility?

Chart 9 > What is the Potential of a Bird Strike Advisory System? > ATM R&D Seminar 2019 > 02 July 2019
Concept

3000 ft AGL

t = 0.5

t = 1.5

t = 2.5

t = 3.5

Bird Strike Advisory System

Increased Safety? deterministic? Decreased Capacity?

Feasibility?

fast-time simulations
Simulation Environment

Fast-Time Simulation of Air Traffic and Bird Movements

3000 ft AGL

Airport Area

spring summer autumn winter
Simulation Environment
Demo Video
The diagram outlines the approach to developing a bird strike advisory system. It starts with the current state of having no advisory system. The verification process leads to a nominal state, which involves collision avoidance algorithms, verification requirements, and CDR logic. The inclusion of risk distribution and feasibility considerations ensures the system's viability and safety.
Approach

no advisory system

verification

collision avoidance algorithm

nominal

verification

requirements

CDR logic

including risk distribution

Feasibility
Simulation Environment

Outcome

- ca. 3x higher bird strike rate
- seasonal correspondence
- reproducibility (MC simulations)

source: Metz, et al. 2017
Approach

no advisory system

verification

collision avoidance algorithm

nominal

verification

requirements

CDR logic

including risk distribution

Feasibility
Key Questions

• how many bird strikes can be prevented?
• how many false alerts are generated?
• how much delay is generated?
• what are the economic consequences?
Collision Avoidance Algorithm

Concept

Based on:

```
broad phase
filter for potential conflicts
```

```
narrow phase
detect conflicts
```

```
conflict resolution
reschedule aircraft
```

```
revised air traffic scenarios
```

Air traffic scenarios → bird trajectories → broad phase (filter for potential conflicts) → narrow phase (detect conflicts) → conflict resolution (reschedule aircraft) → revised air traffic scenarios.
Collision Avoidance Algorithm
Concept – broad phase

1. generate four-dimensional grid
   • time: 10 seconds
   • latitude & longitude: 1000 m
   • altitude: 100 m

2. assign birds to tiles

3. test against aircraft
   • only birds sharing tiles are relevant

4. forward birds to test to narrow phase
CDR Algorithm
Concept – broad phase

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Collision Avoidance Algorithm
Concept – narrow phase

1. compare trajectories from begin to end of shared tile
   • resolution:
     • head-on conflict with vmax (radius smallest aircraft, 0.1 sec)
Collision Avoidance Algorithm
Concept – Conflict Resolution

- reschedule aircraft
  - 5 seconds
  - minimum separation to previous arrival
Simulation Specifications

- protected zones birds and aircraft

- simulated data

- logging frequencies aircraft trajectories
Simulation Specifications

- protected zones birds and aircraft

source: Metz, et al. 2017
Simulation Specifications

- simulated data
  - birds
    - one week per month within one year
- aircraft
  - airports with one operational runway

<table>
<thead>
<tr>
<th>intensity</th>
<th>number of flights</th>
<th>opening hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>954</td>
<td></td>
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<tr>
<td>medium</td>
<td>501</td>
<td>17 hours</td>
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<tr>
<td>low</td>
<td>305</td>
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Simulation Specifications

- logging frequencies aircraft trajectories

<table>
<thead>
<tr>
<th>iteration identifier</th>
<th>logging frequency lift-off</th>
<th>logging frequency remaining flight</th>
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<tbody>
<tr>
<td>I</td>
<td>10 Hz</td>
<td>2</td>
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<tr>
<td>II</td>
<td>20 Hz</td>
<td>1</td>
</tr>
<tr>
<td>III</td>
<td>20 Hz</td>
<td>2</td>
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</table>

![Diagram](image)
Results

• how many bird strikes can be prevented?

• how many false alerts are generated?

• how much delay is generated?

• what are the economic consequences?
## Results

### Verification

- **Criteria**
  - max 5% remaining strikes
  - max 5% false alerts

<table>
<thead>
<tr>
<th>traffic intensity</th>
<th>strikes baseline</th>
<th>tolerated strikes and false warnings</th>
<th>remaining strikes</th>
<th>false warnings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2/10 Hz</td>
<td>1/20 Hz</td>
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<tr>
<td>high</td>
<td>155</td>
<td>7.75</td>
<td>9</td>
<td>6</td>
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<tr>
<td>medium</td>
<td>70</td>
<td>3.5</td>
<td>2</td>
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<tr>
<td>low</td>
<td>54</td>
<td>2.7</td>
<td>1</td>
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**Results**

**Verification**

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Results

 generated delays

- affected flights: 3.14% (high intensity)
- lost departure slots: 27 (high intensity)
- departures after opening hours: none
## Results

### Economic Consequences

- **Assumptions**
  - Cost per bird strike: €24,947 (FAA)
  - Cost per delay minute: €35 (University of Westminster)

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<thead>
<tr>
<th>Traffic Intensity</th>
<th>Prevented Bird Strikes</th>
<th>Saved Costs</th>
<th>Sum Delay Minutes</th>
<th>Delay Costs</th>
<th>Saved Costs Per Caused Costs</th>
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<tbody>
<tr>
<td>High</td>
<td>149</td>
<td>3,717,103</td>
<td>2,455</td>
<td>85,925</td>
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<td>Medium</td>
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<td>1,696,396</td>
<td>150</td>
<td>5,239</td>
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<tr>
<td>Low</td>
<td>53</td>
<td>1,322,191</td>
<td>19</td>
<td>676</td>
<td>1957</td>
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Summary and Outlook

- simulation environment
  - reproducible number of strikes
- deterministic collision avoidance algorithm
  - 97 % prevented strikes
  - 2 % false warnings
- very limited impact on capacity
- high potential for cost reduction
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next step: including uncertainty in bird movements

Thank you!

Questions?