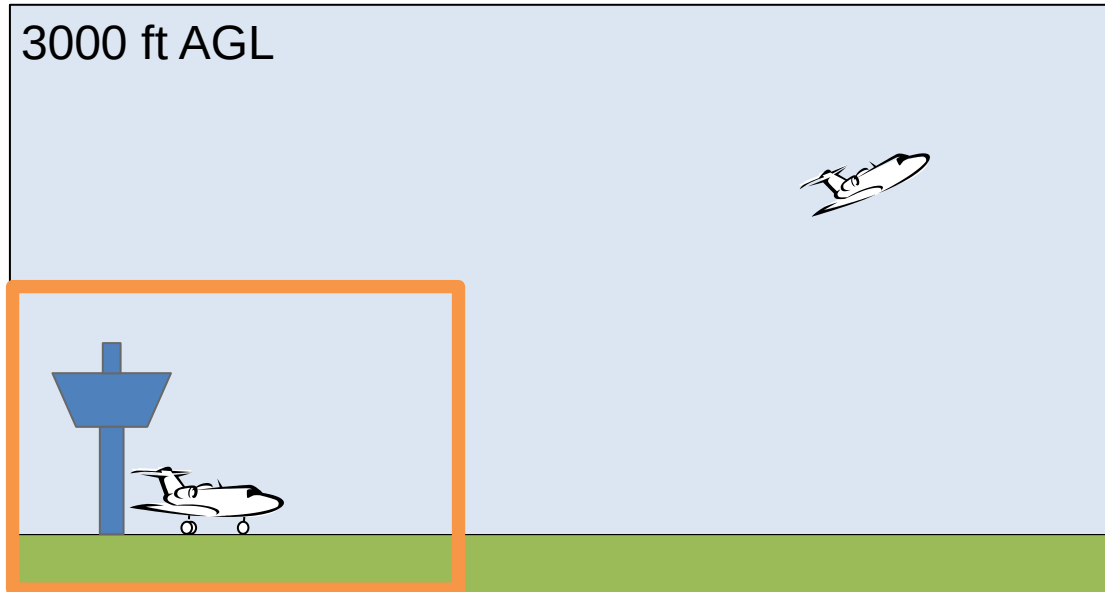


Simulating the Risk of Bird Strikes

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

Motivation

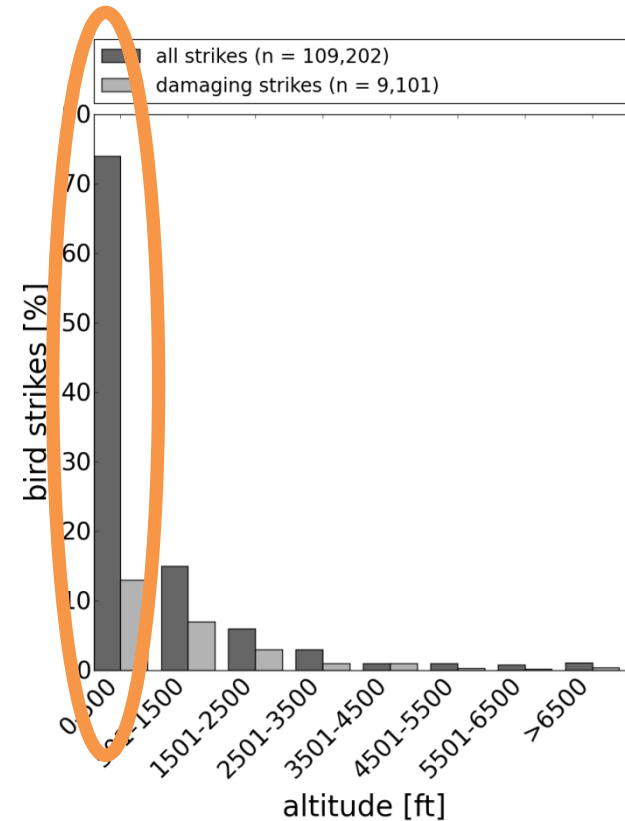
Bird Strike Risk and Mitigation Measures



source: usatoday.com



© Alamy



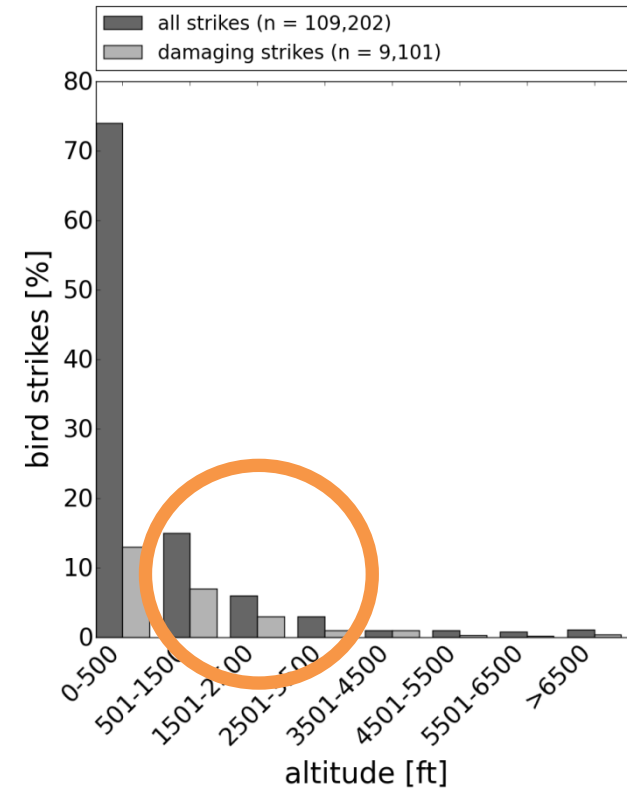
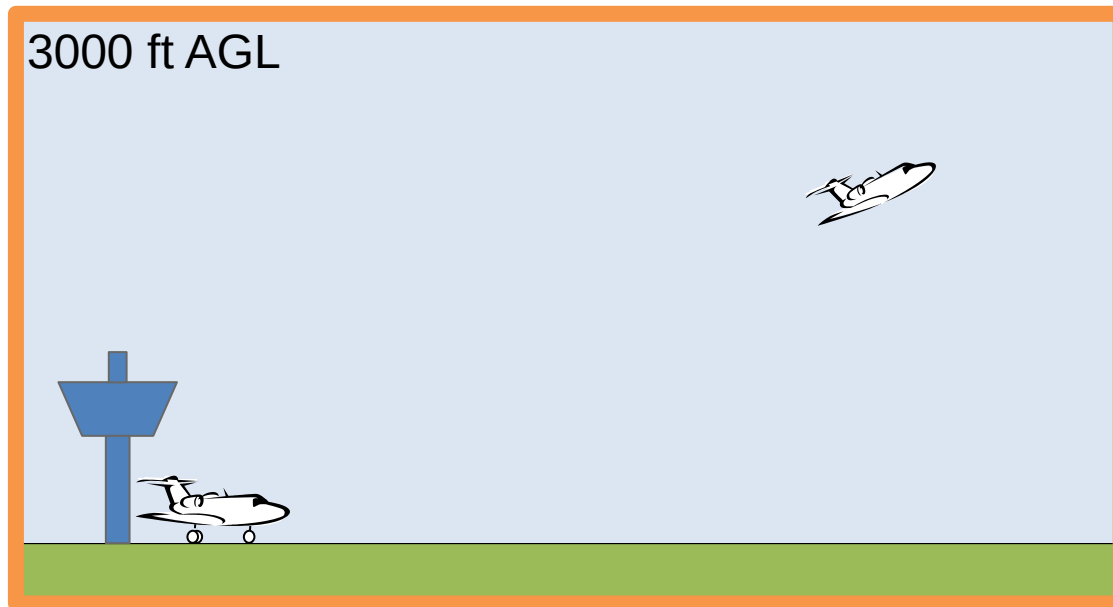
altitude distribution of bird strikes
in the US between 1990 and 2015

source: FAA

source: dailymail.co.uk

Motivation

Bird Strike Risk and Mitigation Measures



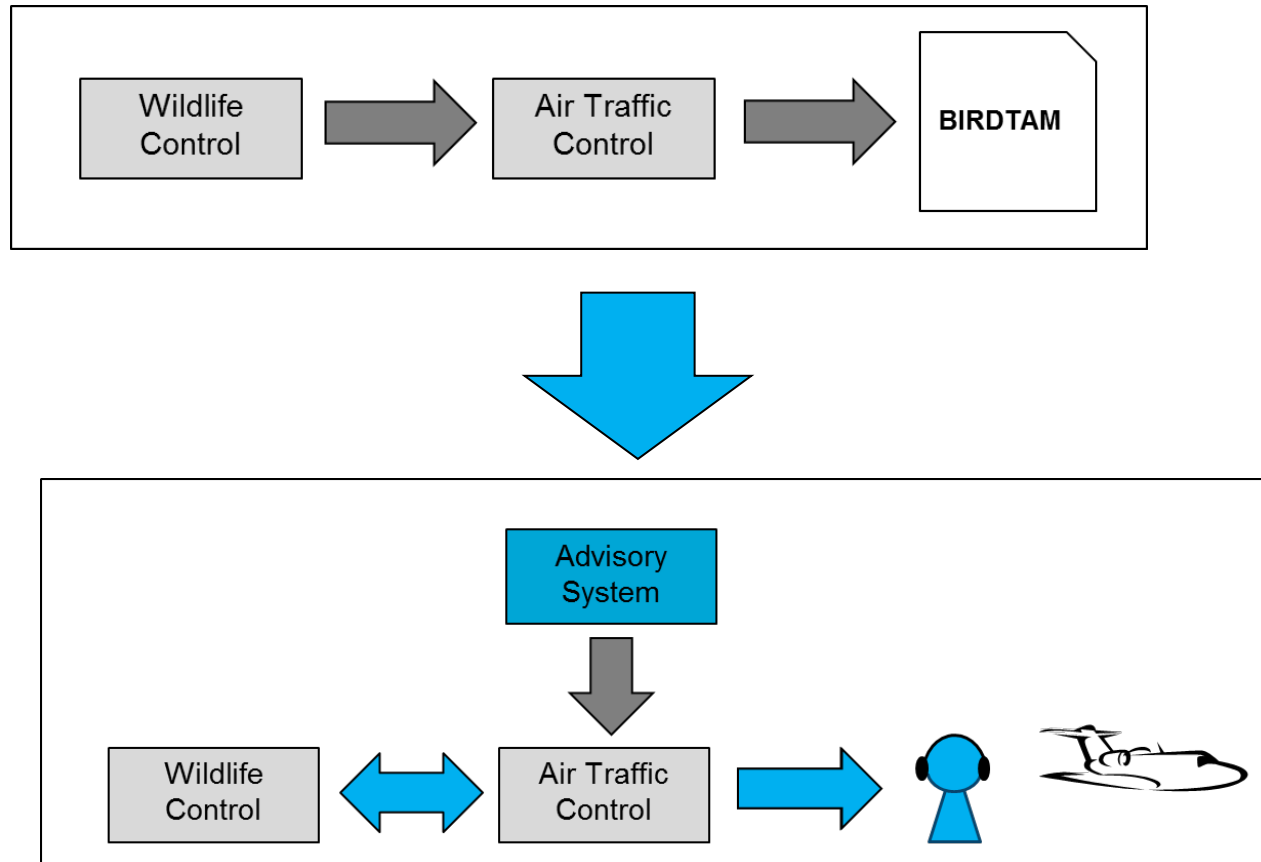
altitude distribution of bird strikes
in the US between 1990 and 2015

source: FAA

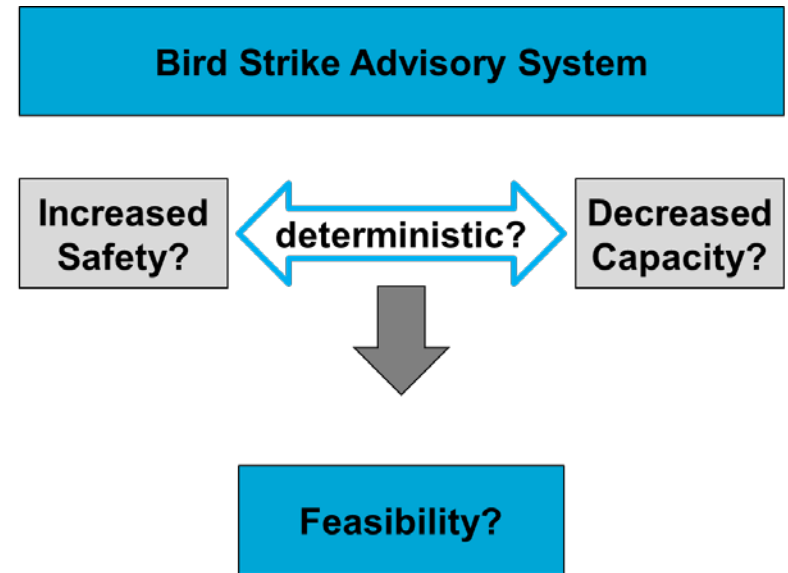
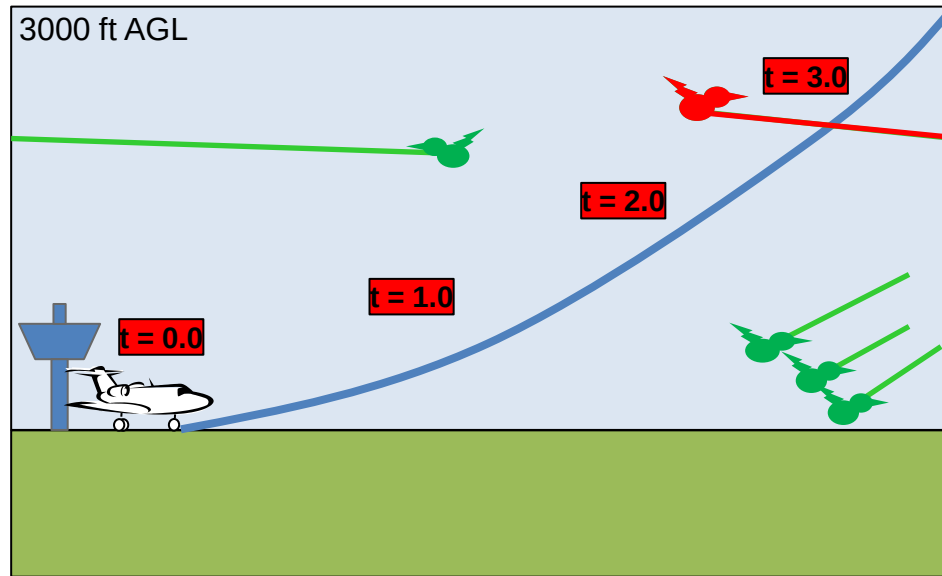
source: cbsnews.com

Motivation

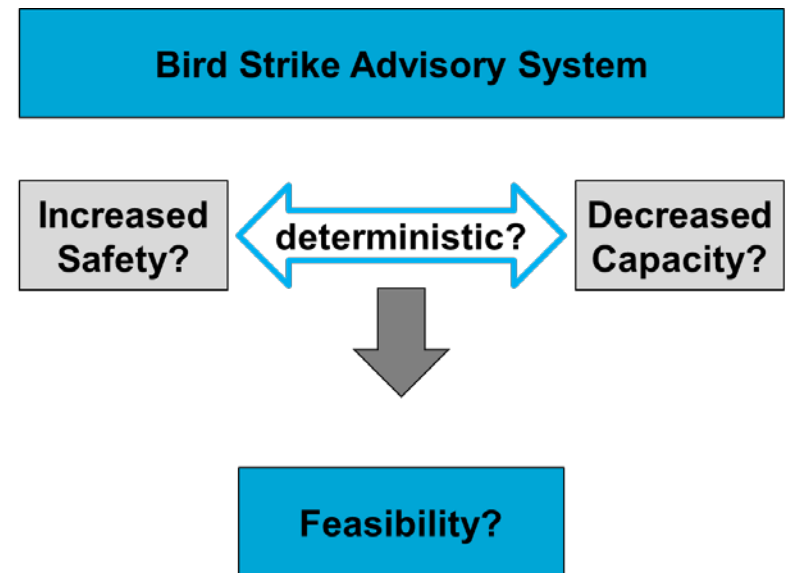
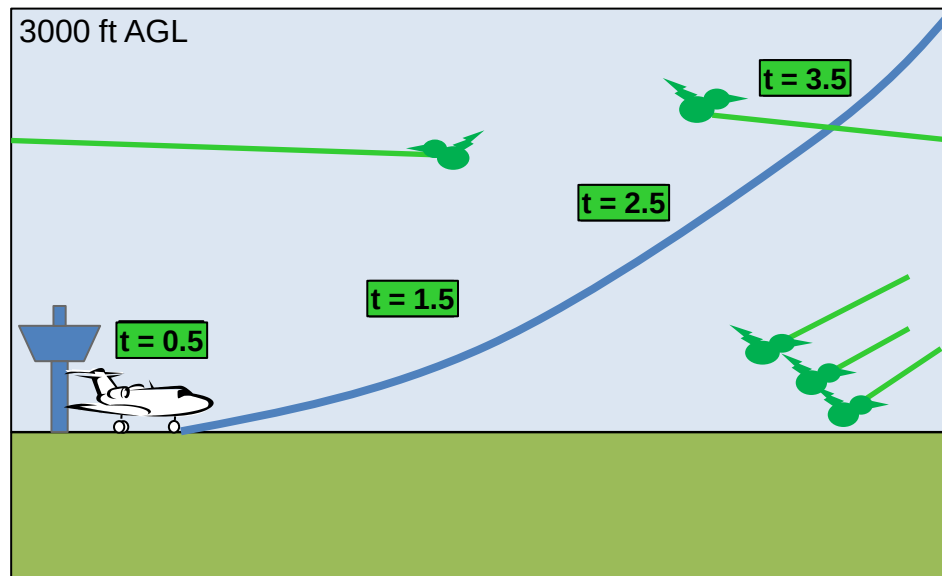
Role of Air Traffic Control



Concept



Concept



fast-time simulations



Fast-Time Simulation Environment

- air traffic simulation platform
- bird movement model
- collision model

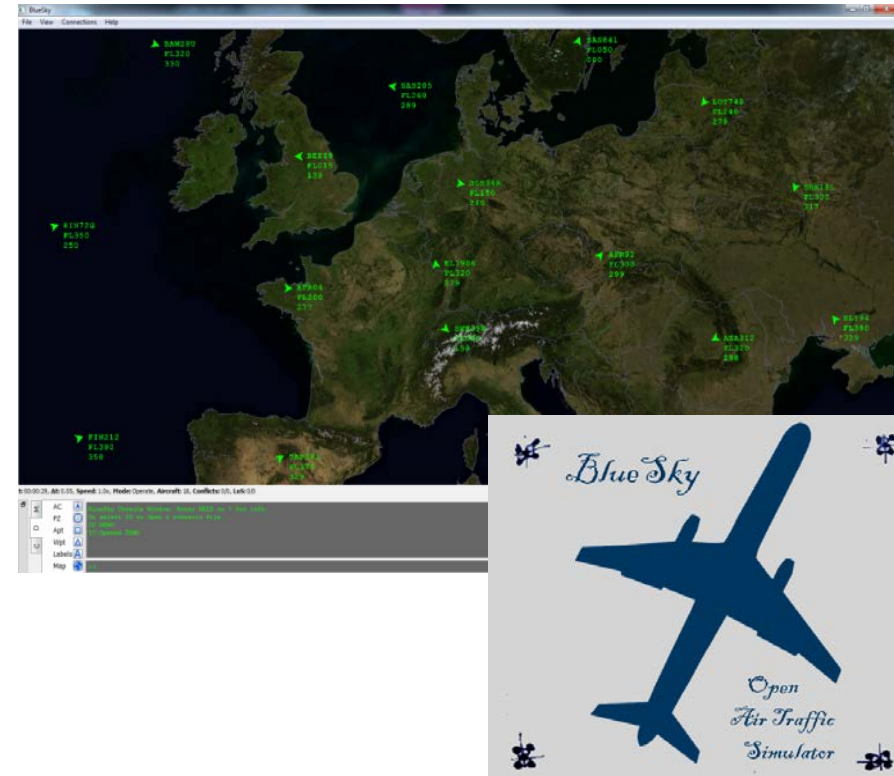


Simulation Environment

Air Traffic Simulation Platform

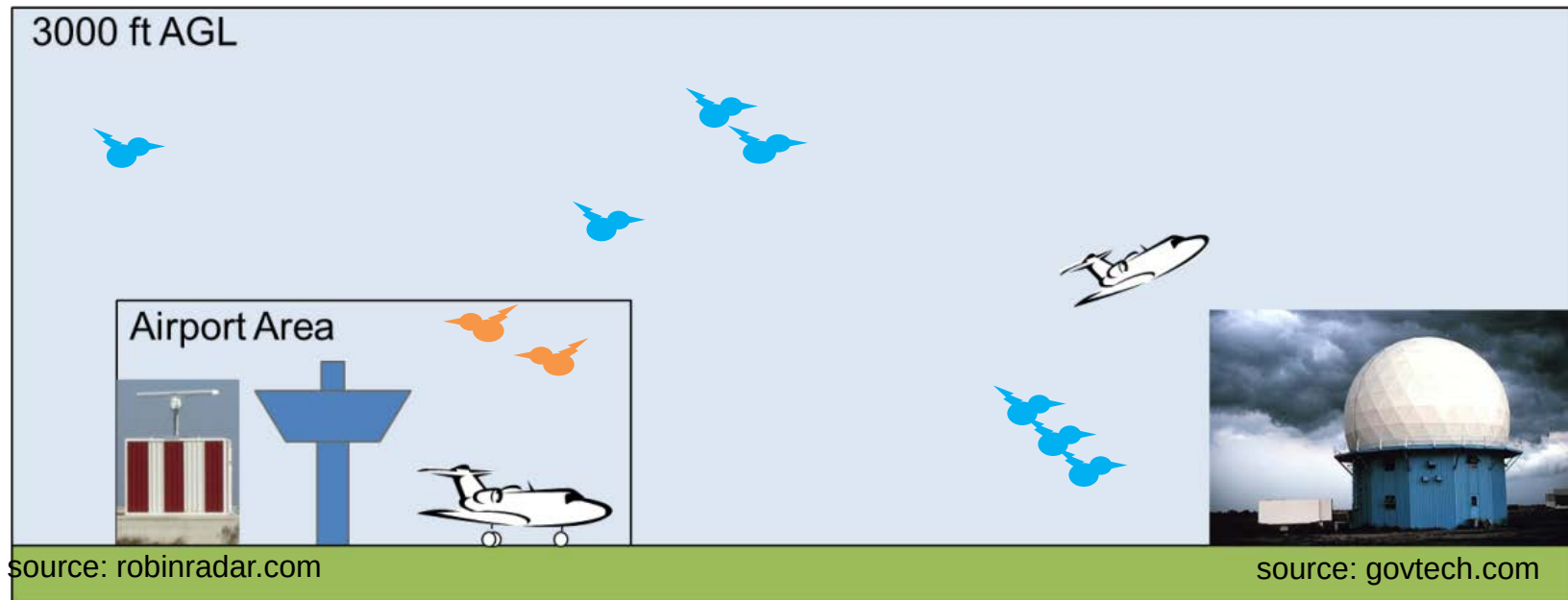
BlueSky Open Air Traffic Simulator

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



Simulation Environment

Bird Movement Model



Royal Netherlands Air Force



Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure and the
Environment*



Simulation Environment

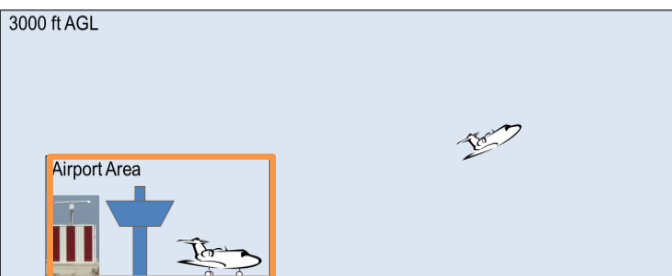
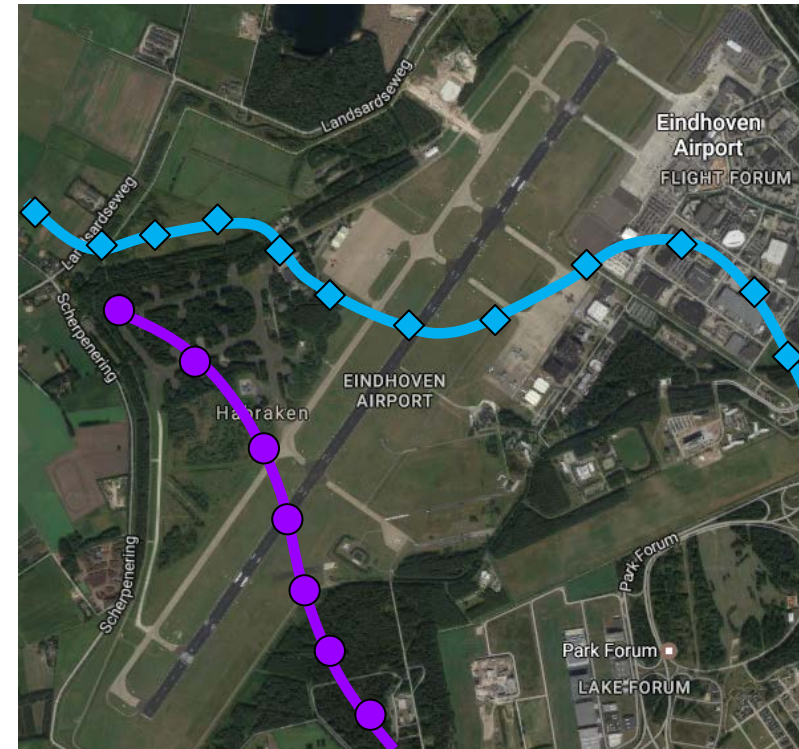
Bird Movement Model: Direct Airport Environment

input

- time-stamped 2D positions
- id
- category

processing

- at least 20 positions per bird
- categories: small, medium, large, flocks



Simulation Environment

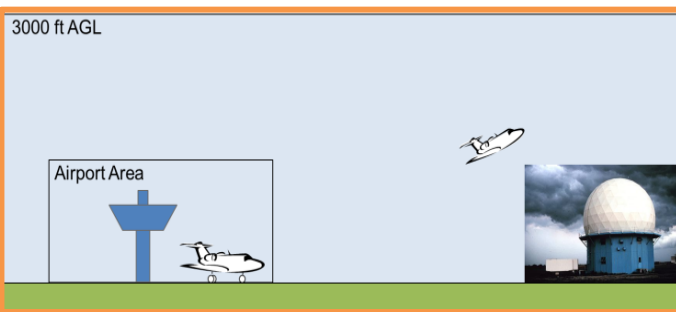
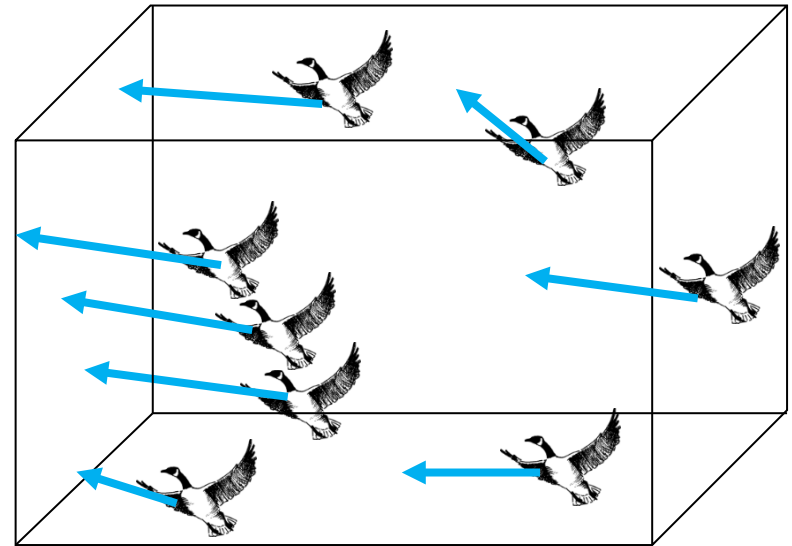
Bird Movement Model: Extended Airport

input

- bird reflectivity
- $$\eta = \overline{\rho_{bird} \sigma_{bird}} \left[\frac{cm^2}{km^3} \right]$$
- velocities in u and v direction

processing

- bird number ($\sigma_{bird} = 11 \text{ cm}^2$)
- constant speed ($SD = 5 \frac{m}{s}$)
- constant direction ($SD = 45^\circ$)

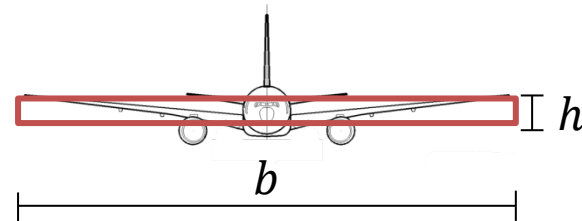
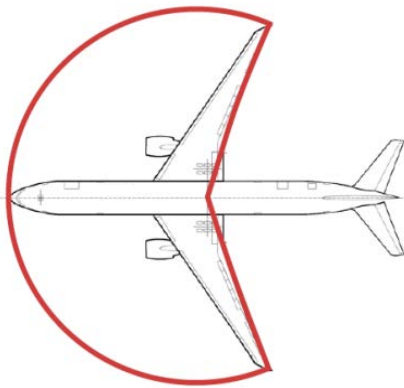


Method based on

- van Gasteren et al. 2008
- Dokter et al. 2010
- Lensink & Kwak 1985
- Hüppop et al. 2006

Simulation Environment

Collision Model: Protected Zone Aircraft



$$S_{front} = b * h = \underbrace{(b - 2 * r_f) * h_w}_{\text{wings}} + \underbrace{n_e * r_e^2 * \pi}_{\text{engines}} + \underbrace{r_f^2 * \pi}_{\text{fuselage}}$$

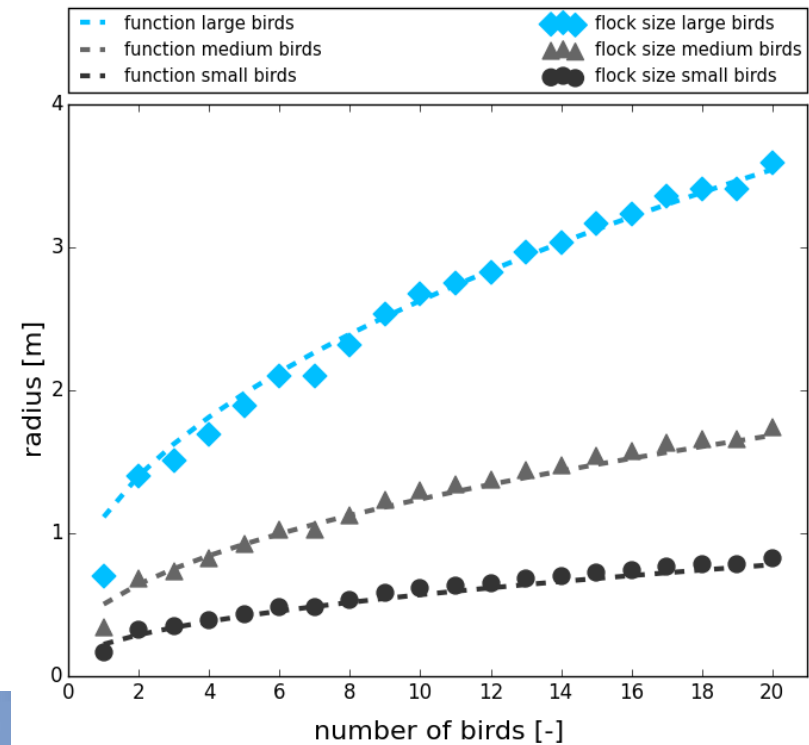


Simulation Environment

Collision Model: Protected Bird



$$r = \sqrt{n_{birds}} * \frac{b}{2} + c$$

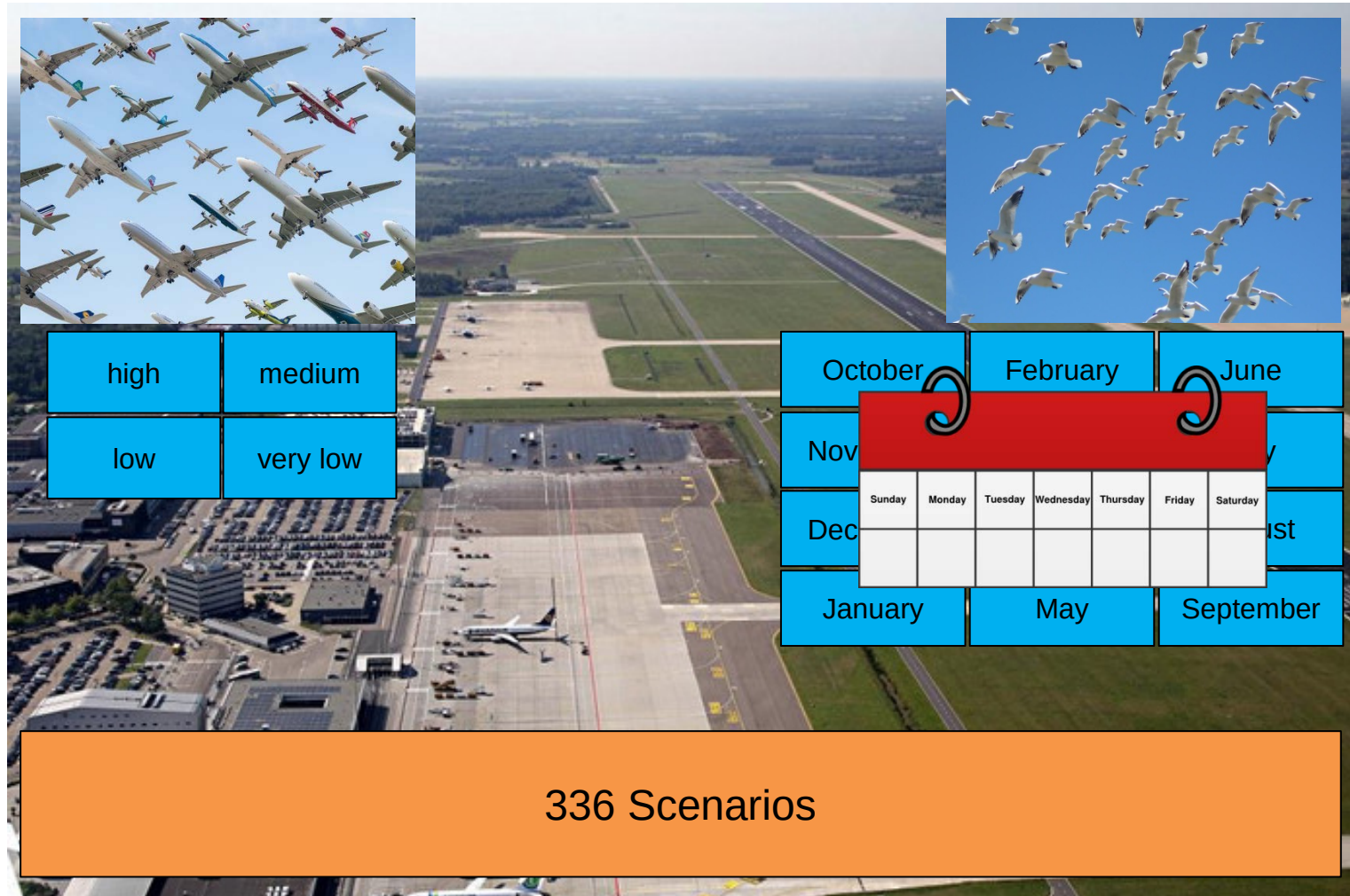


based on Graham 1996



Verification

Simulation Setup



Results

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

Air Traffic Intensity	Bird Strike Rate
high	21.59
medium	19.48
low	21.78
very low	15.07
<i>Eindhoven (reference)*</i>	<i>12.33</i>



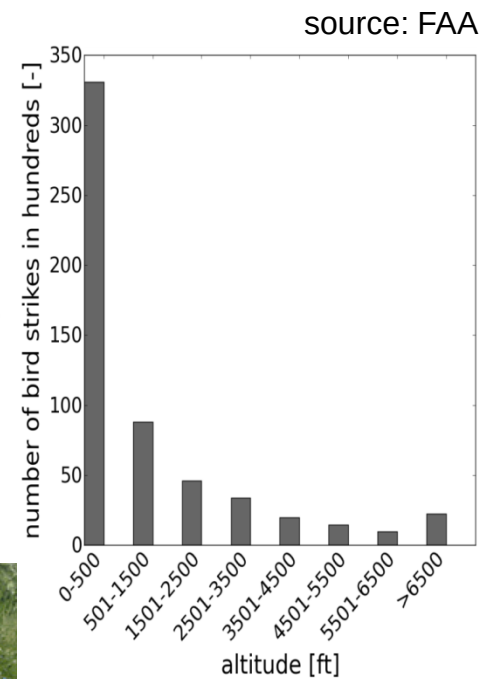
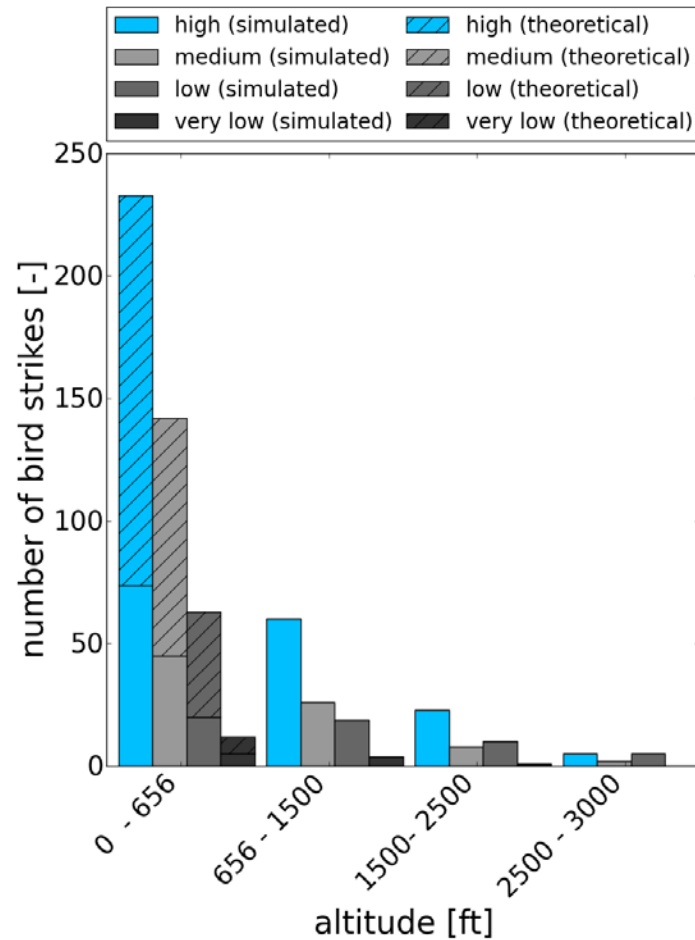
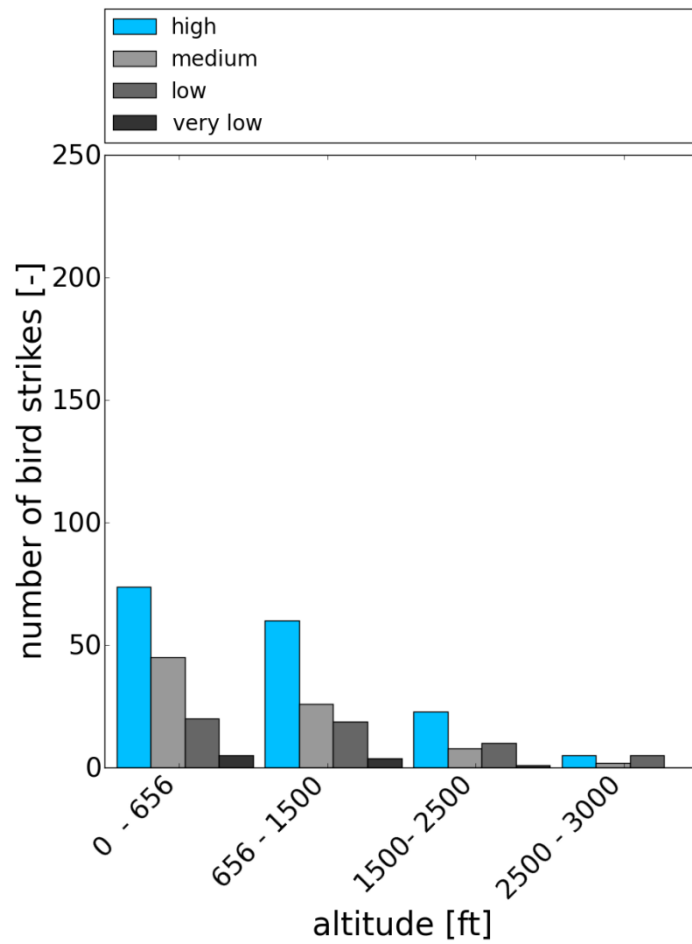
last-minute
escapes?
unreported
strikes?

* average for the period from 2007 to 2016



Results

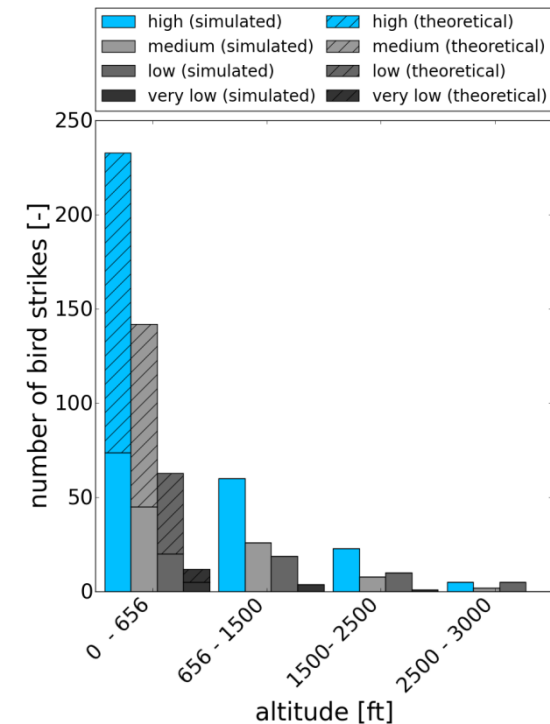
Altitude Distribution



Results

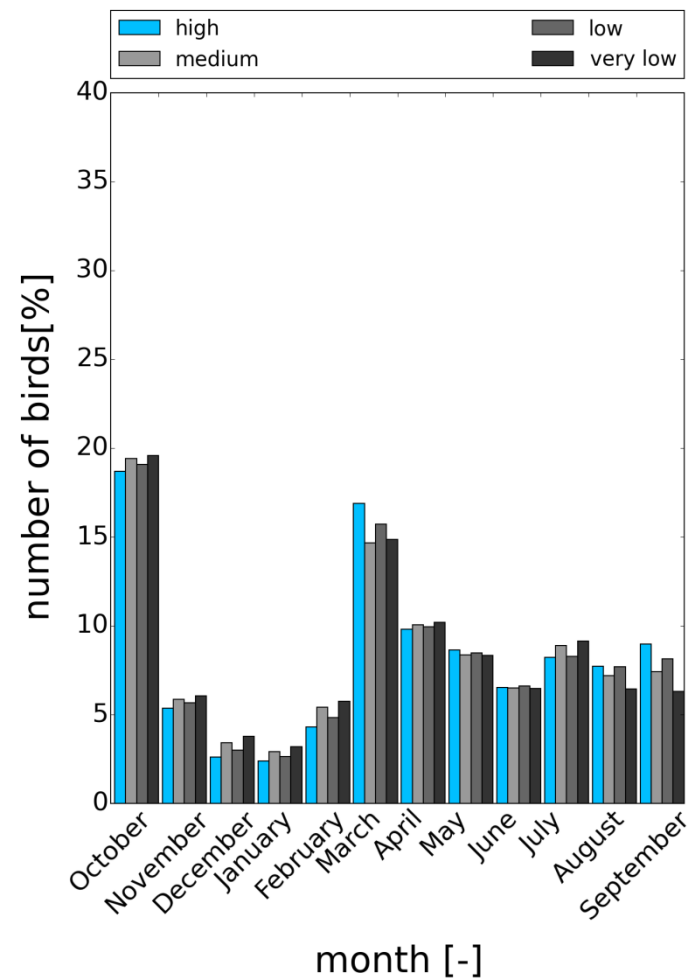
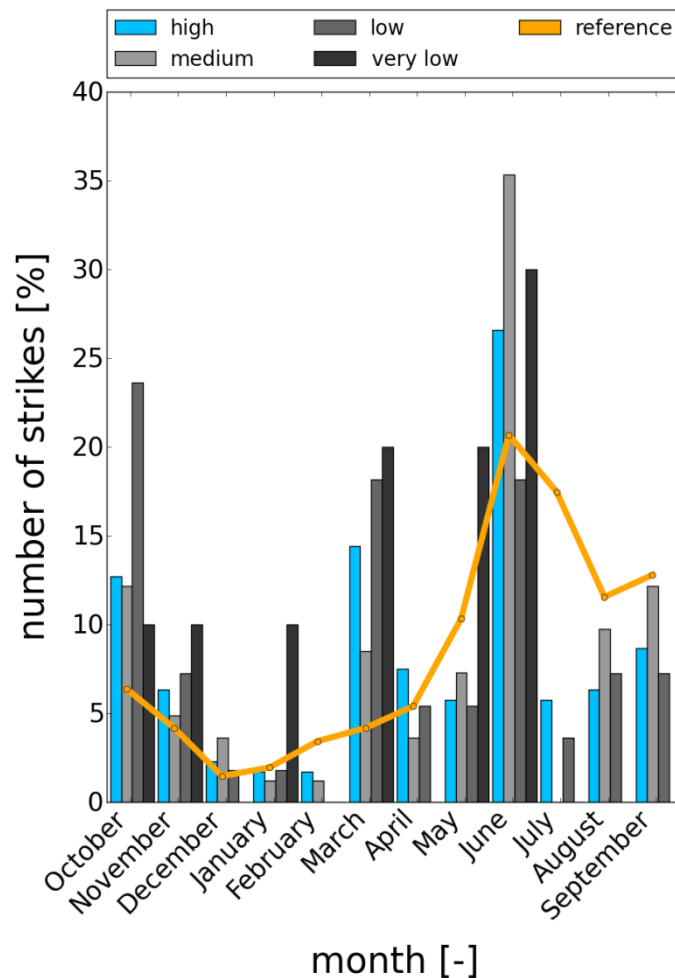
Bird Strike Rate and Altitude Distribution

Airport	Bird Strike Rate	Bird Strike Rate (theoretical)
high	21.59	41.43
medium	19.48	42.43
low	21.78	38.25
very low	15.07	25.62
<i>Eindhoven (reference)</i>	12.33	



Results

Seasonal Distribution

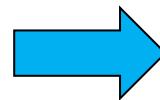


Conclusions

- simulation environment developed
 - bird movement and collision model

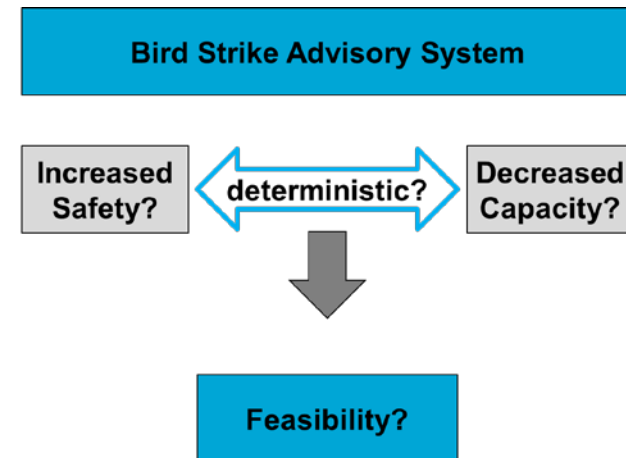
- promising results achieved

- bird strike rate
- altitude distribution
- seasonal distribution



Monte Carlo
Simulations

- next step
 - develop collision avoidance algorithm



Thanks!



Questions?