

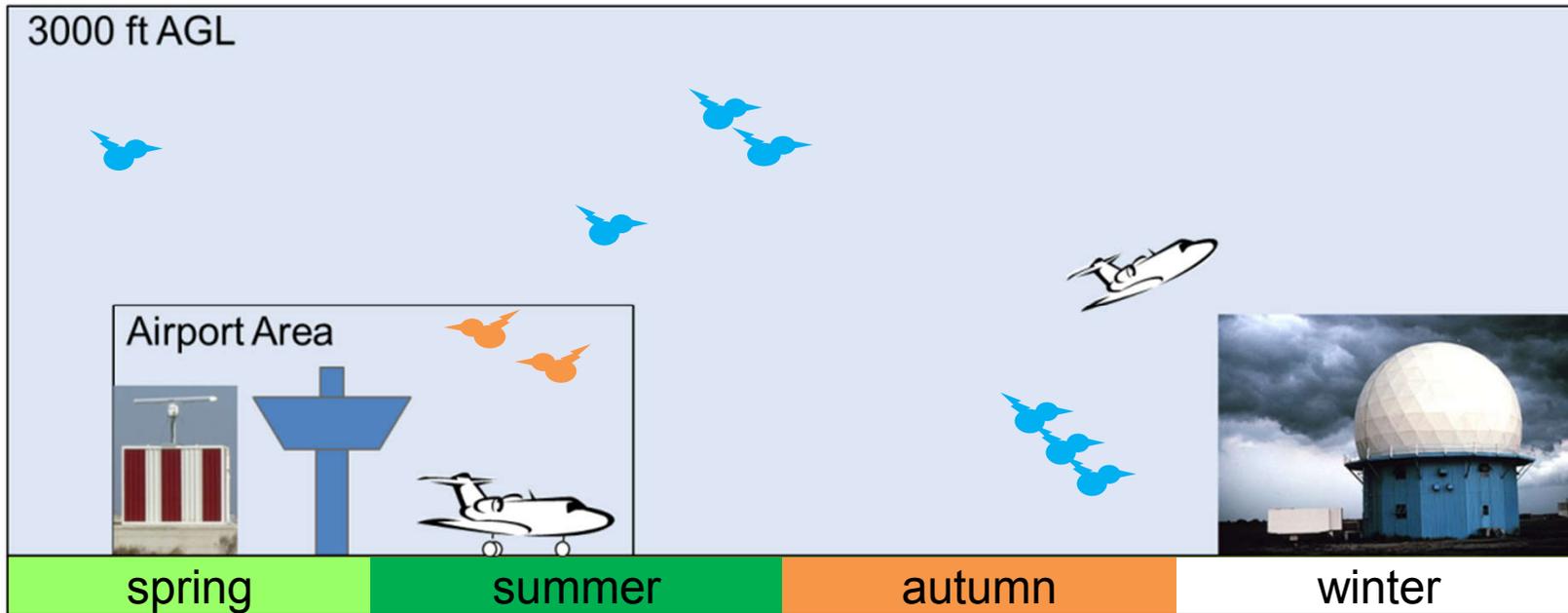
Bird Strike Prevention – An Operational Approach

Isabel C. Metz,
13 August 2019
North American Bird Strike Conference



Simulation Environment

Fast-Time Simulation of Air Traffic and Bird Movements



Royal Netherlands Air Force



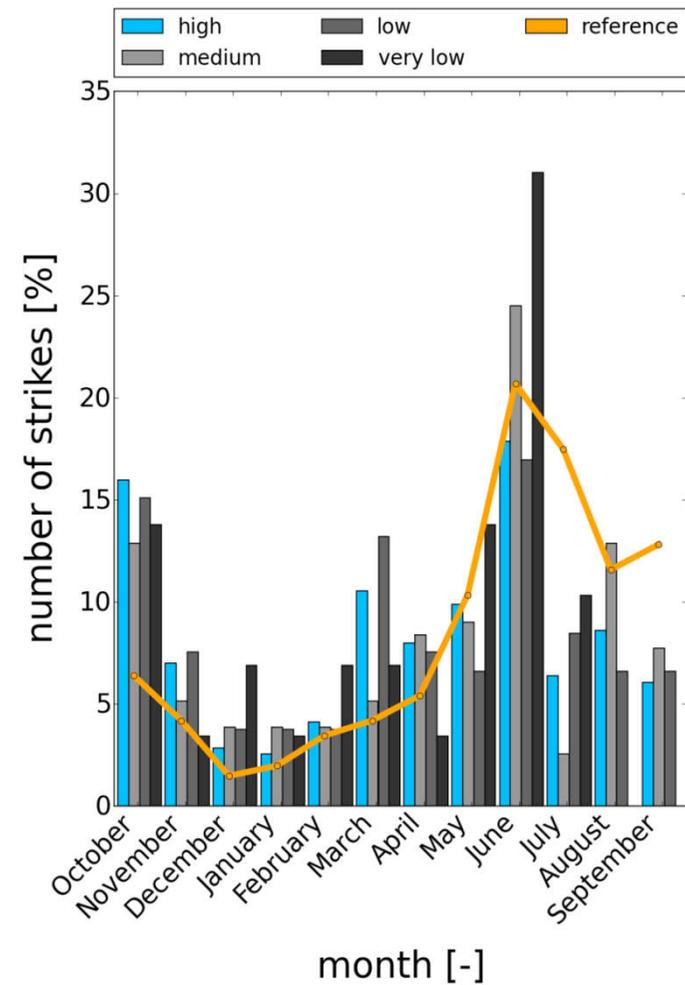
Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment



Simulation Environment

Outcome

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



Applicability of the Model

→ analysis of bird strike risk

→ analysis of risk-reducing measures



Applicability of the Model

→ analysis of bird strike risk



Thursday

→ analysis of risk-reducing measures



Applicability of the Model

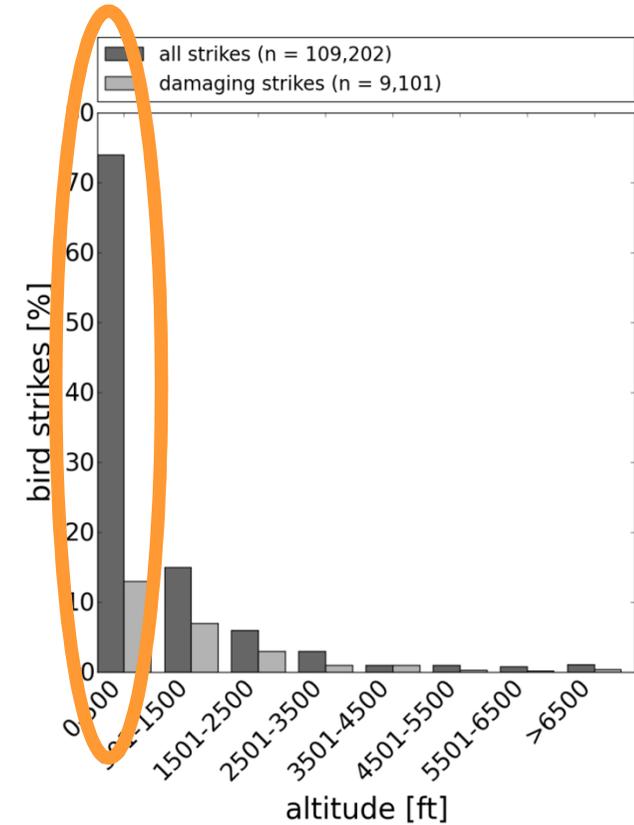
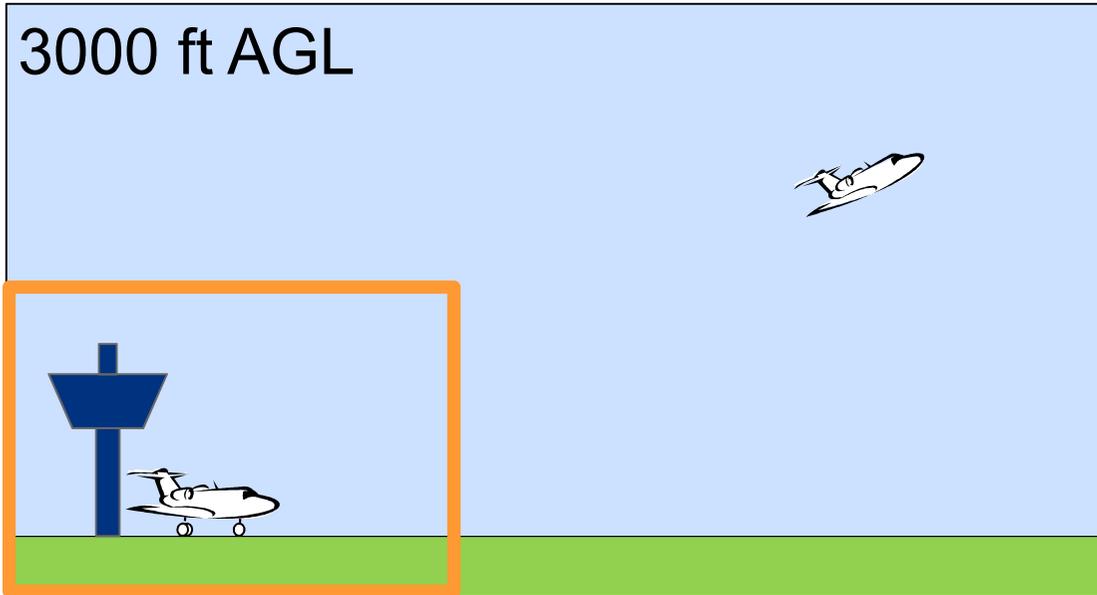
→ analysis of bird strike risk

→ analysis of risk-reducing measures



Motivation

Bird Strike Risk

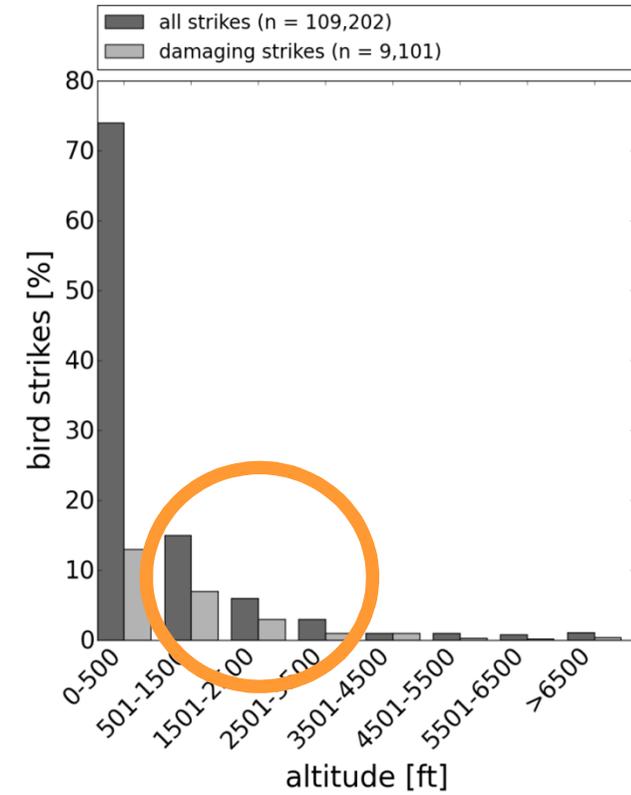
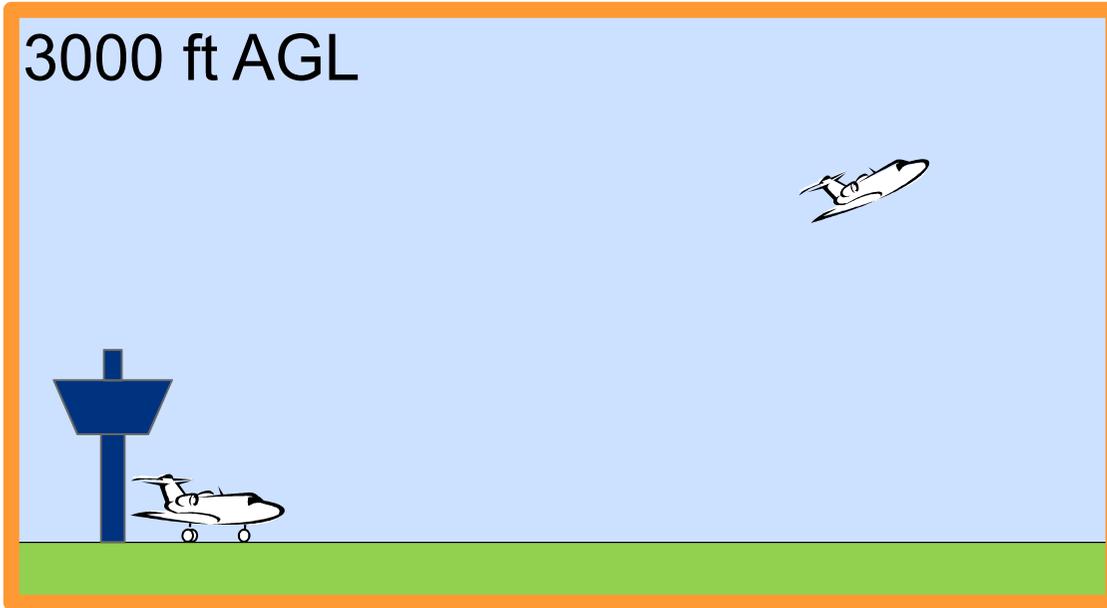


Source: FAA



Motivation

Bird Strike Risk

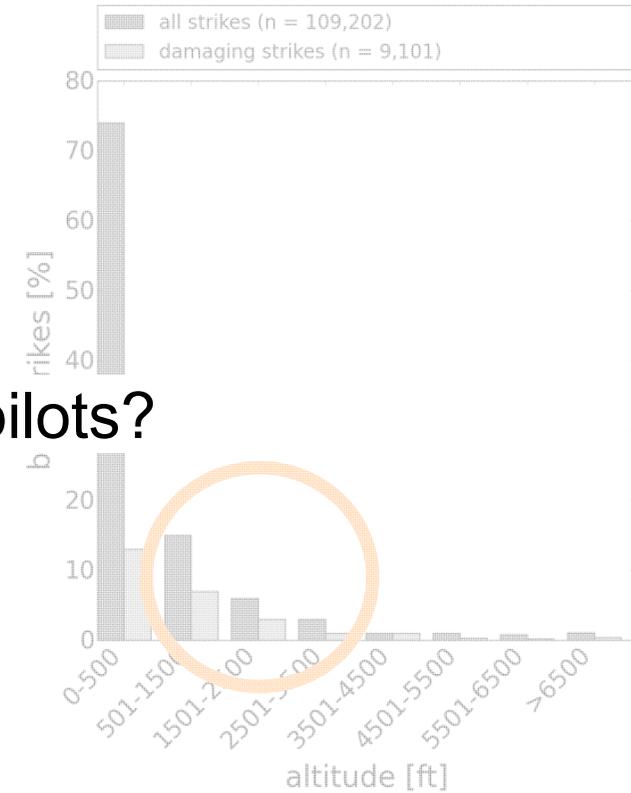


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Motivation

Bird Strike Risk



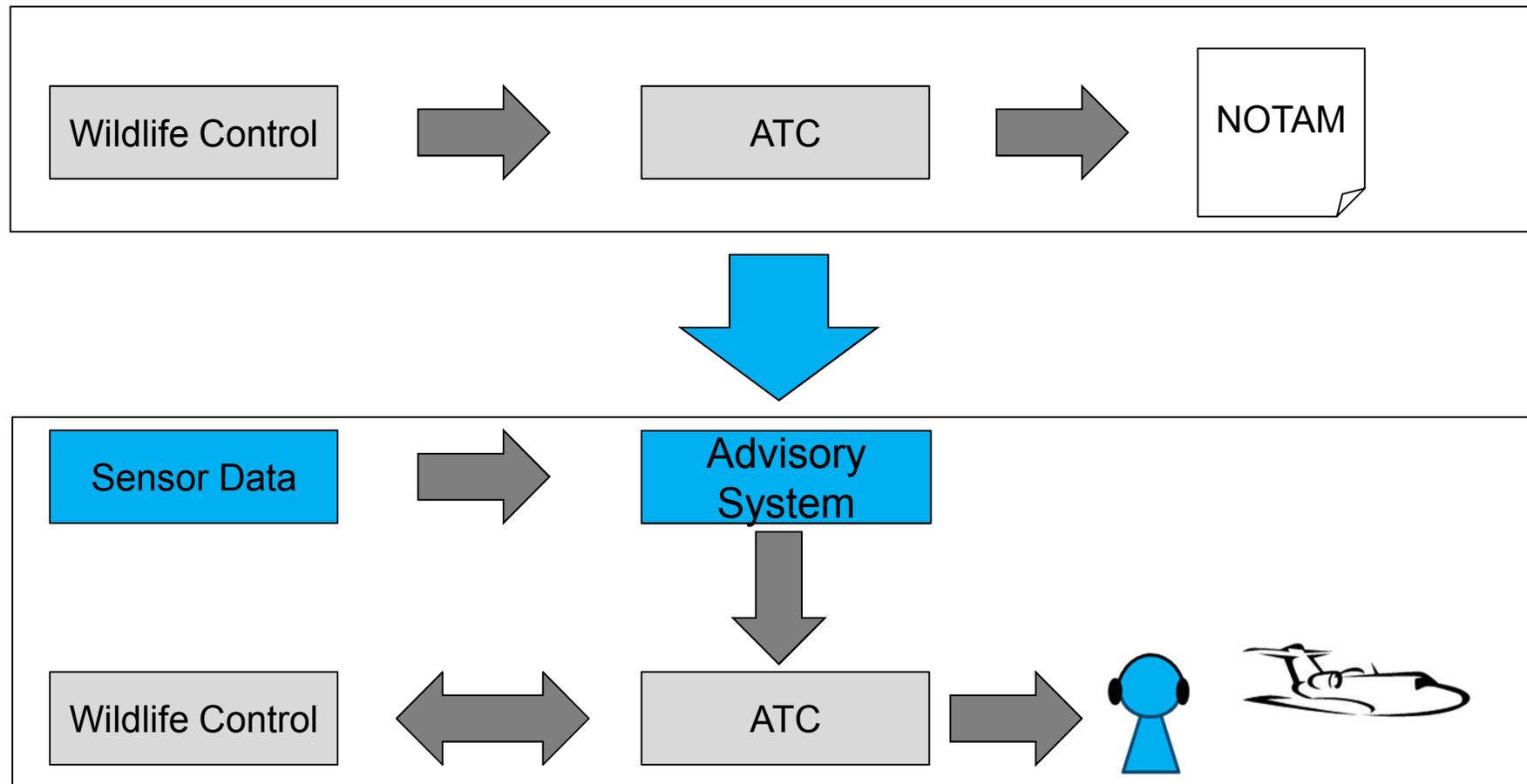
Altitude distribution of bird strikes in the US between 1990 und 2015

Source: FAA

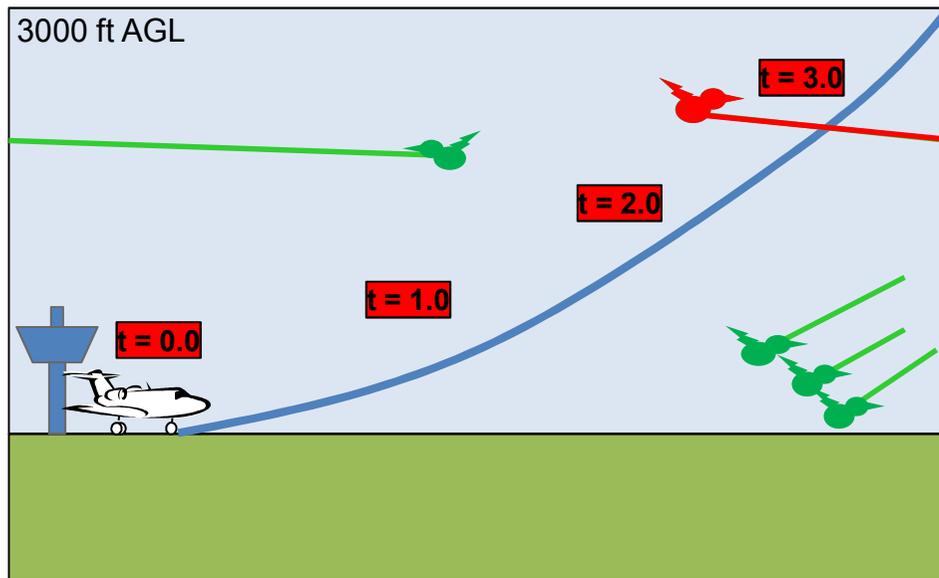


Motivation

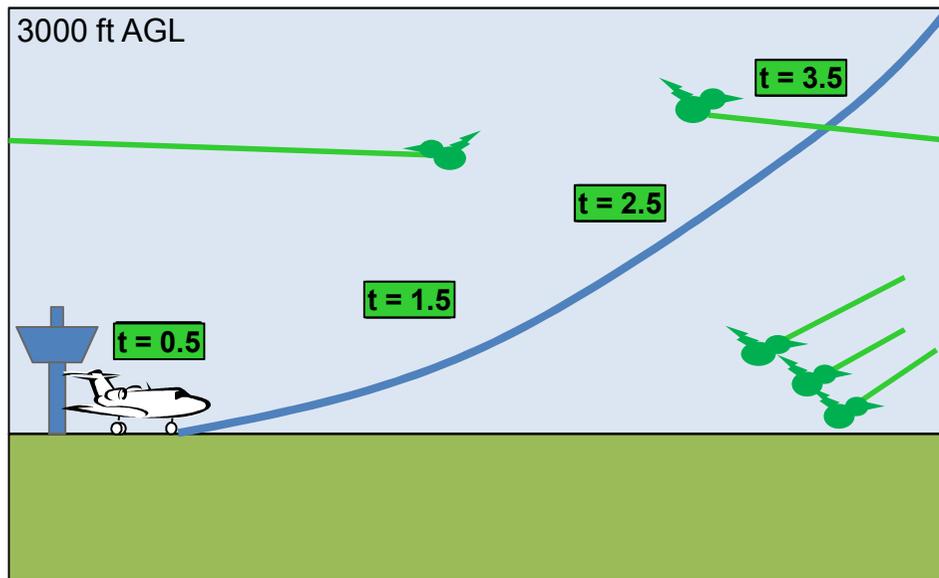
Involving ATC and Pilots



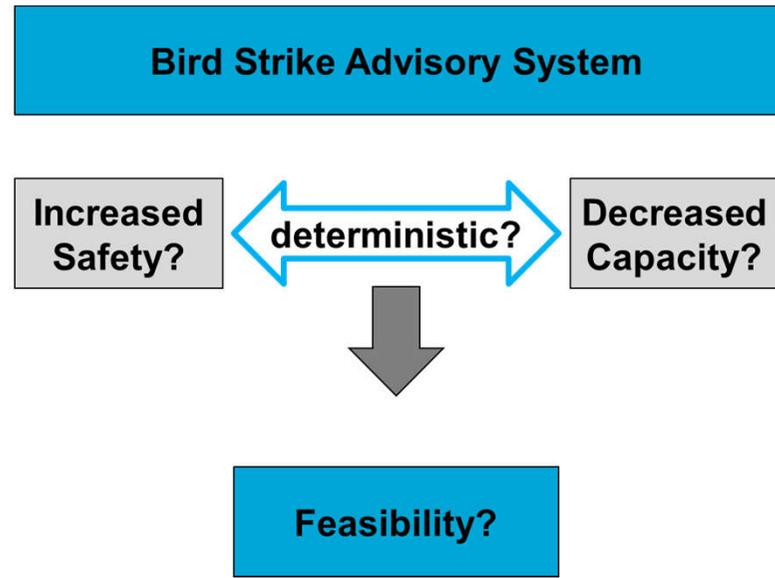
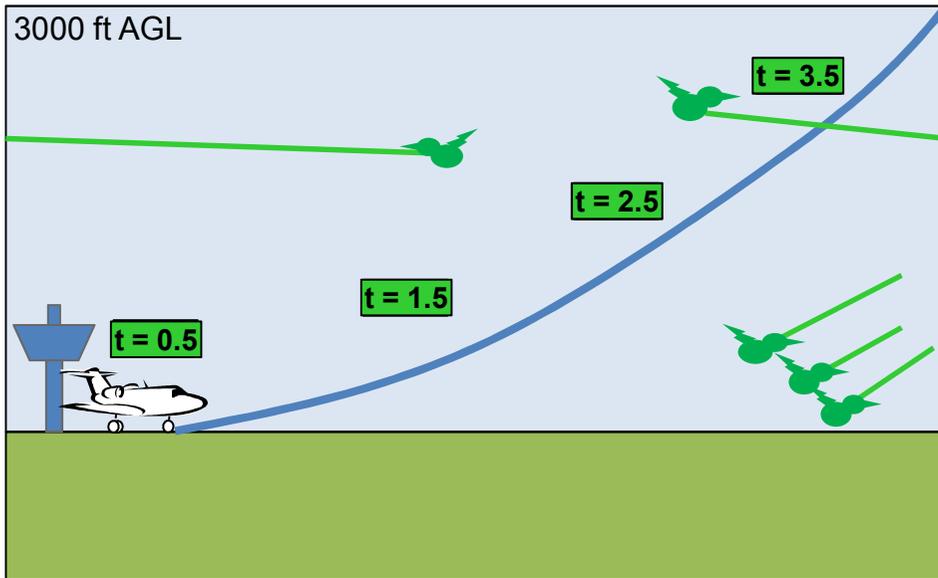
Concept



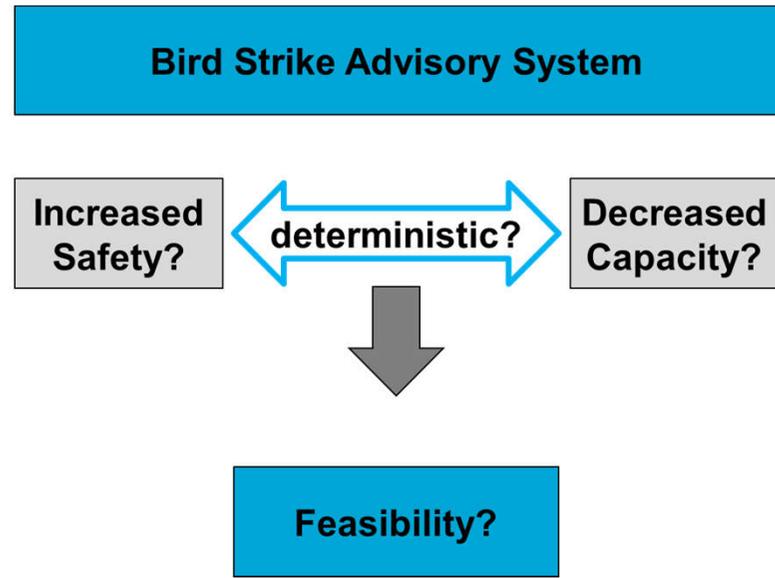
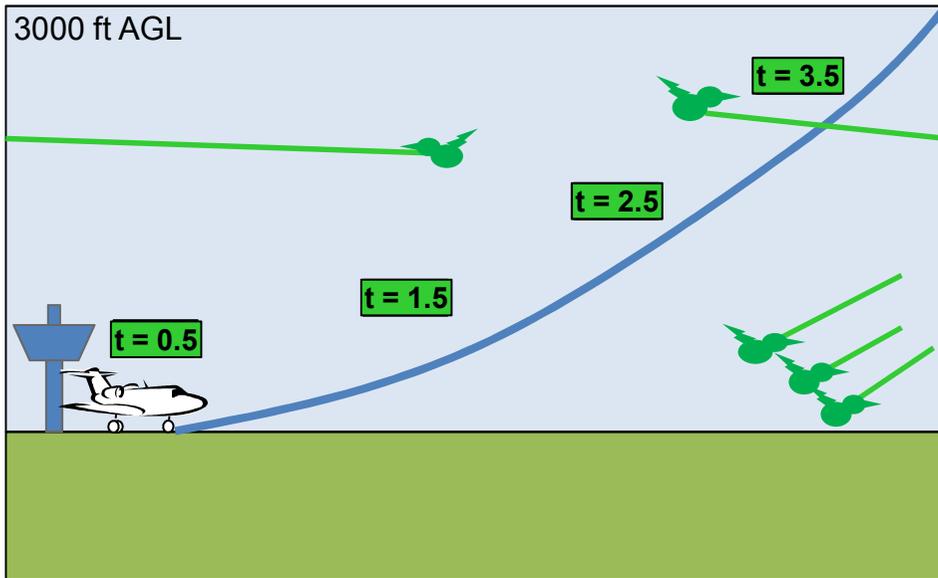
Concept



Concept



Concept

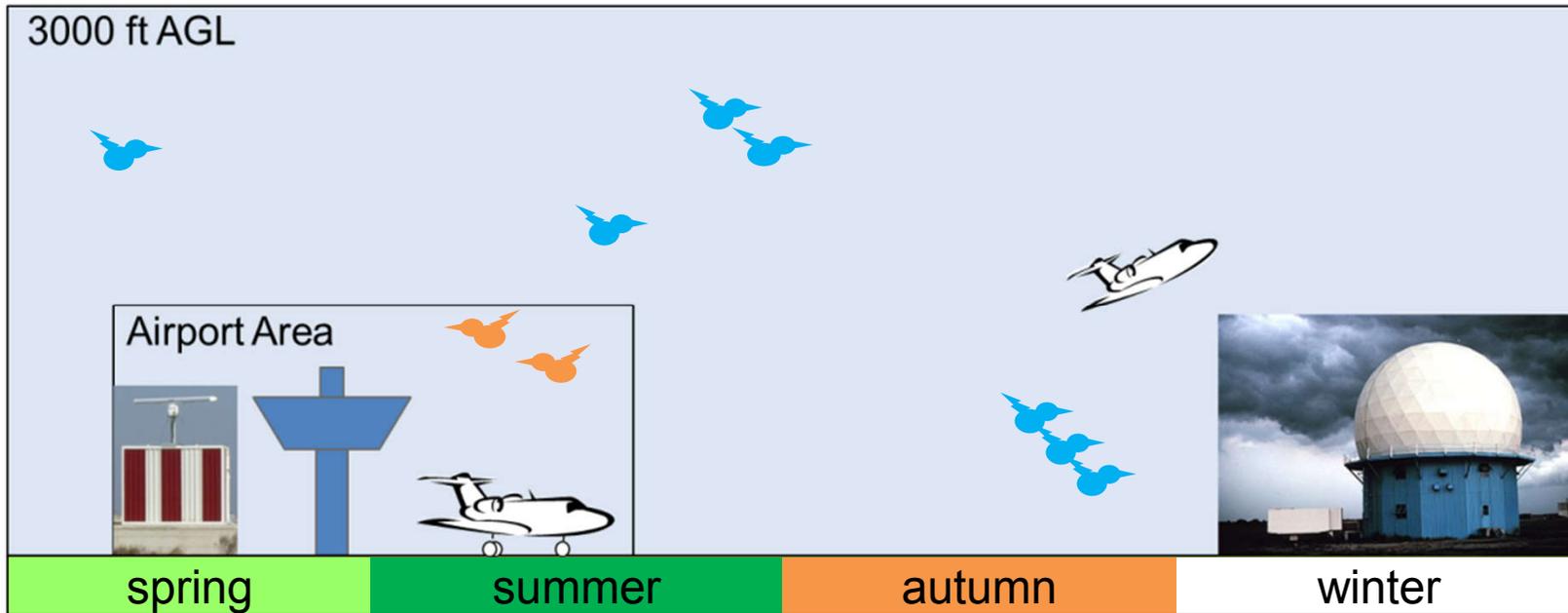


fast-time simulations



Simulation Environment

Fast-Time Simulation of Air Traffic and Bird Movements



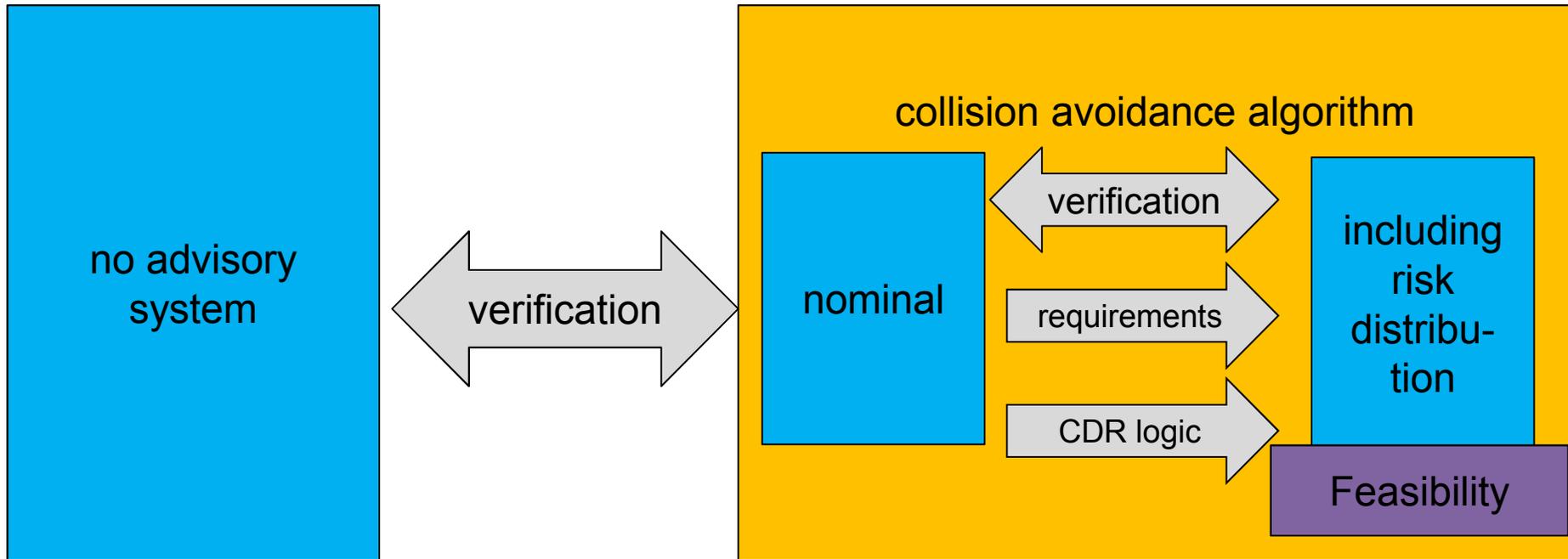
Royal Netherlands Air Force



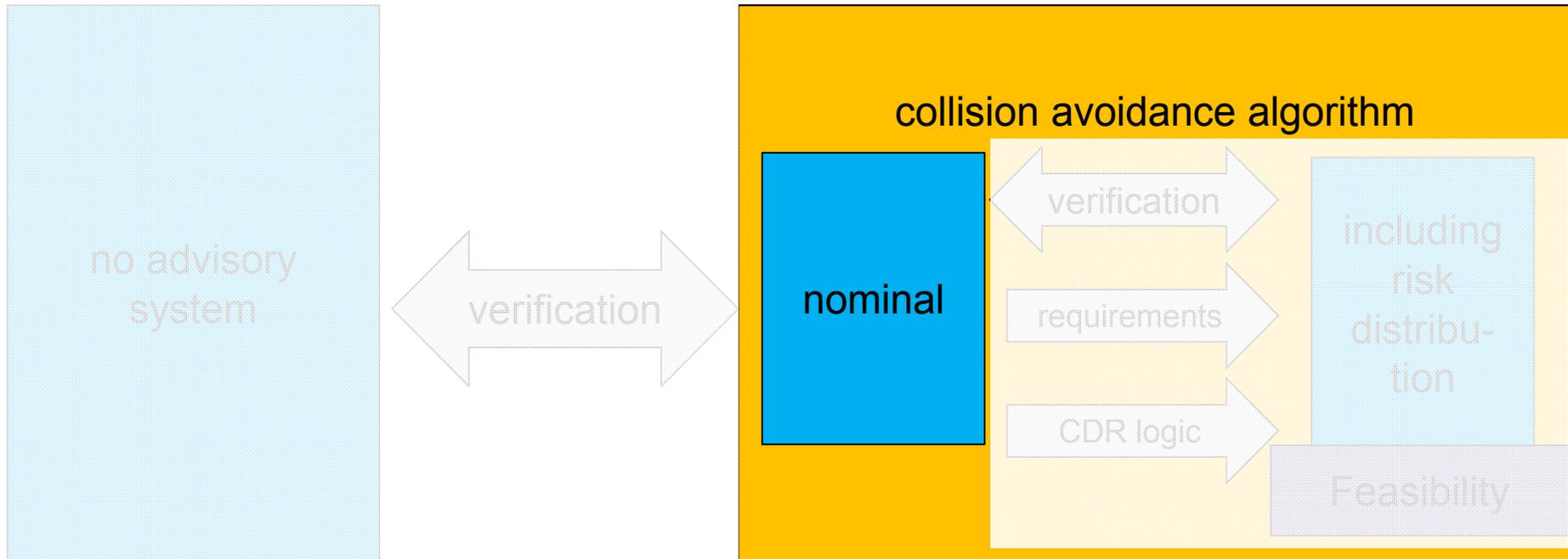
Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the
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Approach



Approach



Key Questions

- how many bird strikes can be prevented?
- how many false alerts are generated?

verification

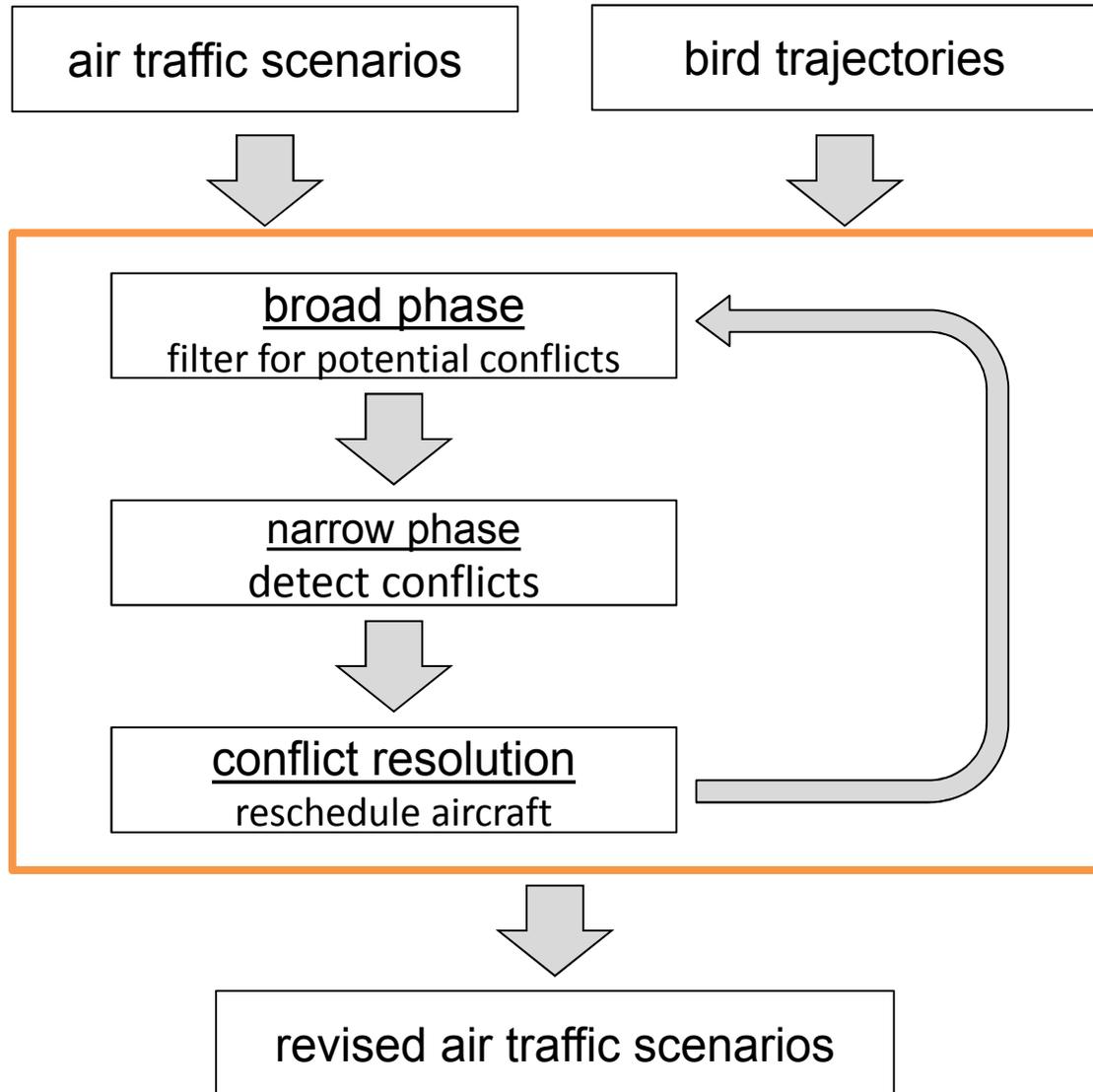
- how much delay is generated?
- what are the economic consequences?

SAFETY
CAPACITY



Collision Avoidance Algorithm

Concept



based on
Kuenz, Alexander. *High Performance Conflict Detection and Resolution for Multi-Dimensional Objects*. DLR-Forschungsbericht Vol. 2015. No. 31. 2015.



Collision Avoidance Algorithm

Concept – broad phase

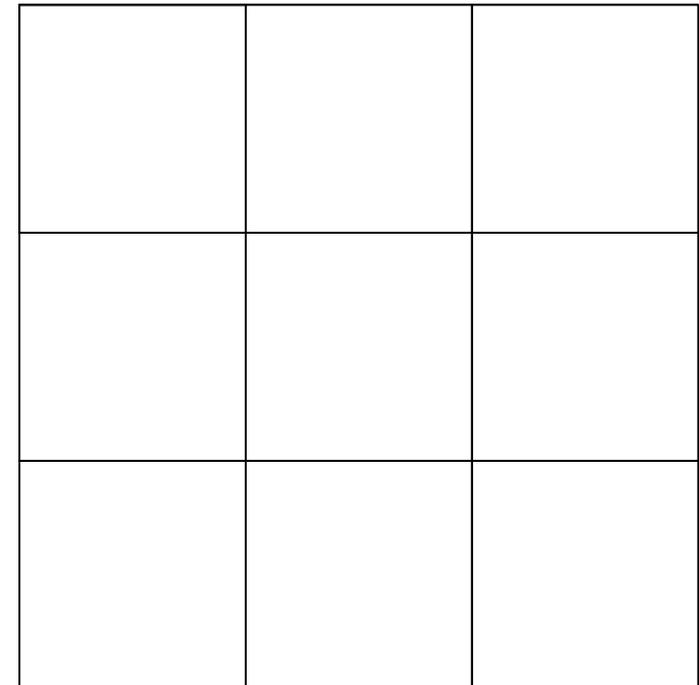
1. generate four-dimensional grid
 - time: 10 seconds
 - latitude & longitude: 1000 m
 - altitude: 100 m
2. assign birds to tiles
3. test against aircraft
 - only birds sharing tiles are relevant
4. forward birds to test to narrow phase



Collision Avoidance Algorithm

Concept – broad phase

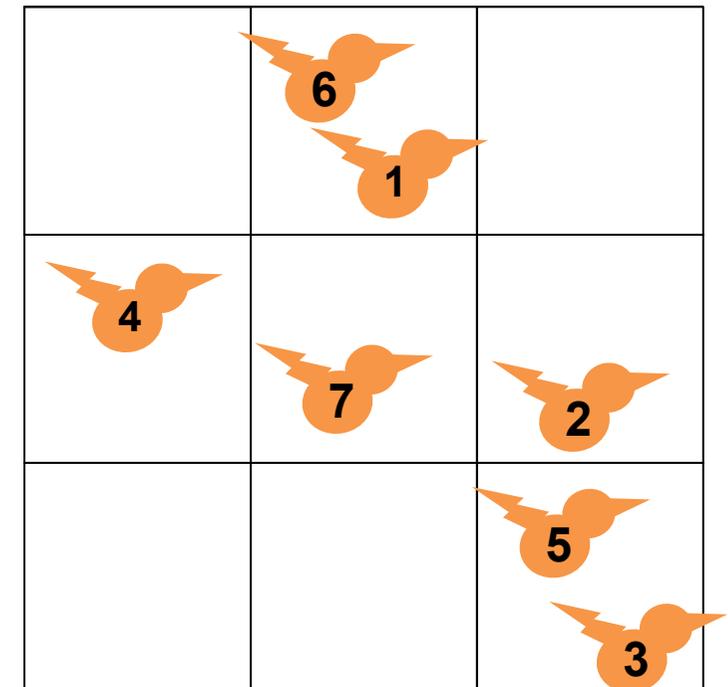
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Collision Avoidance Algorithm

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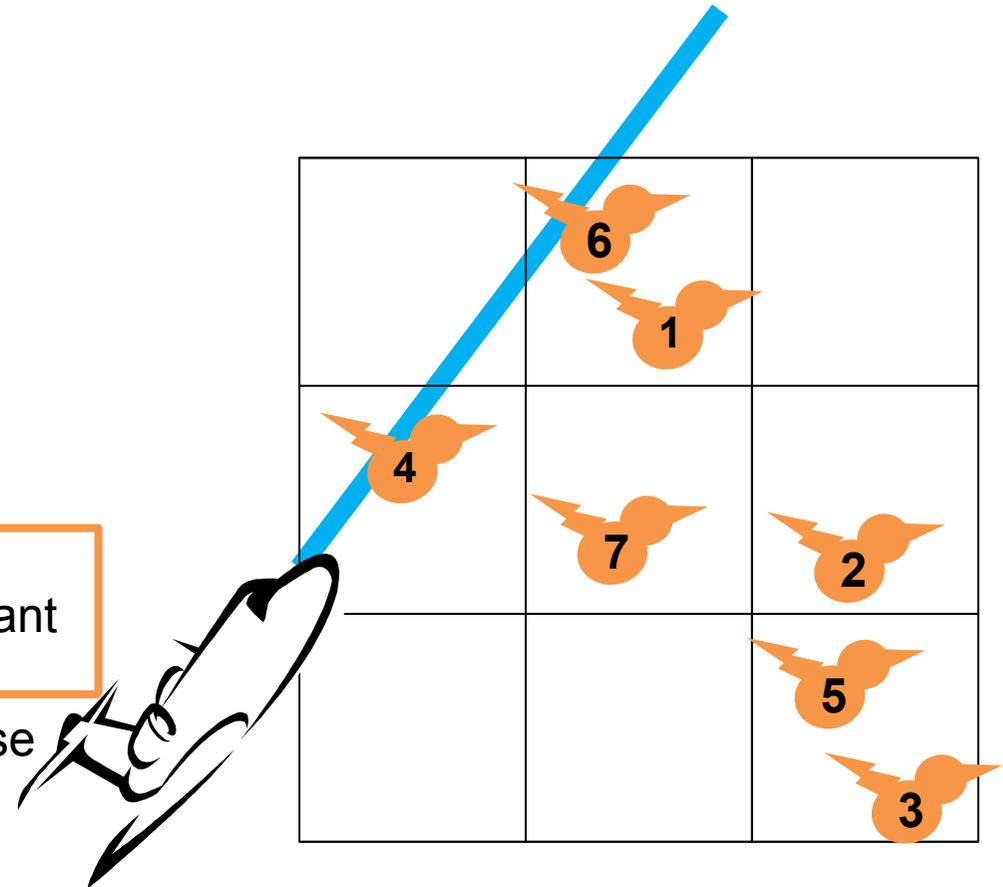
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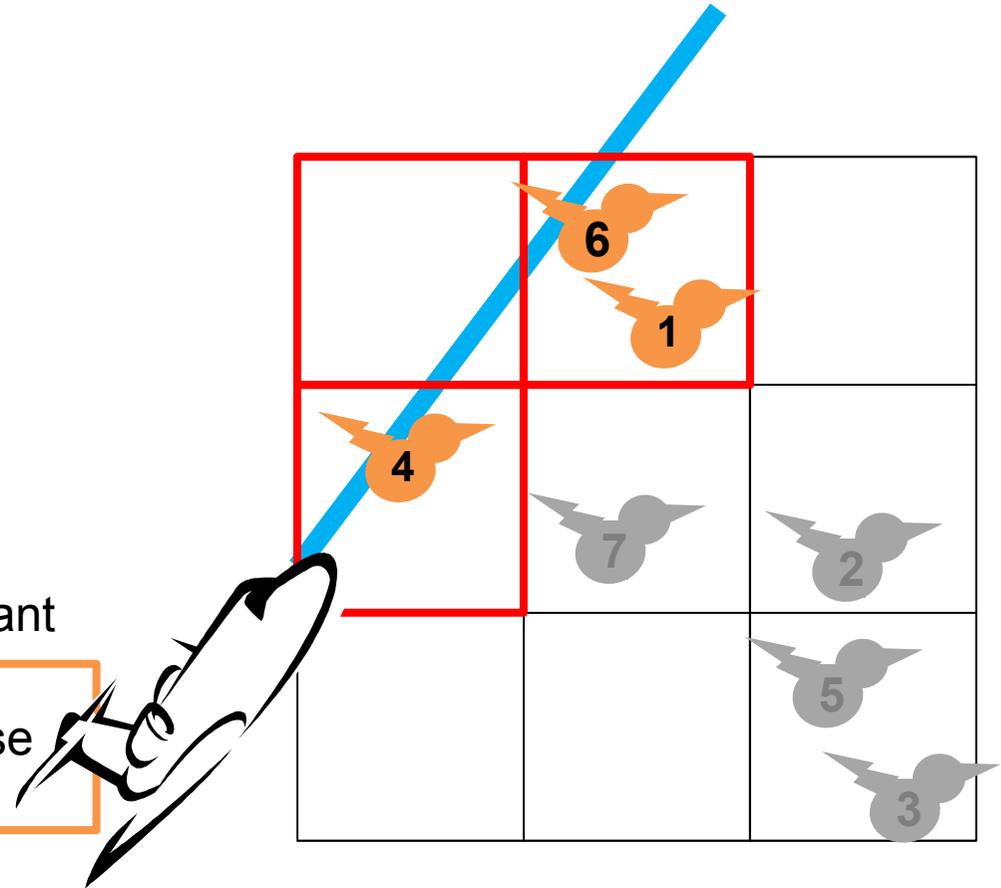


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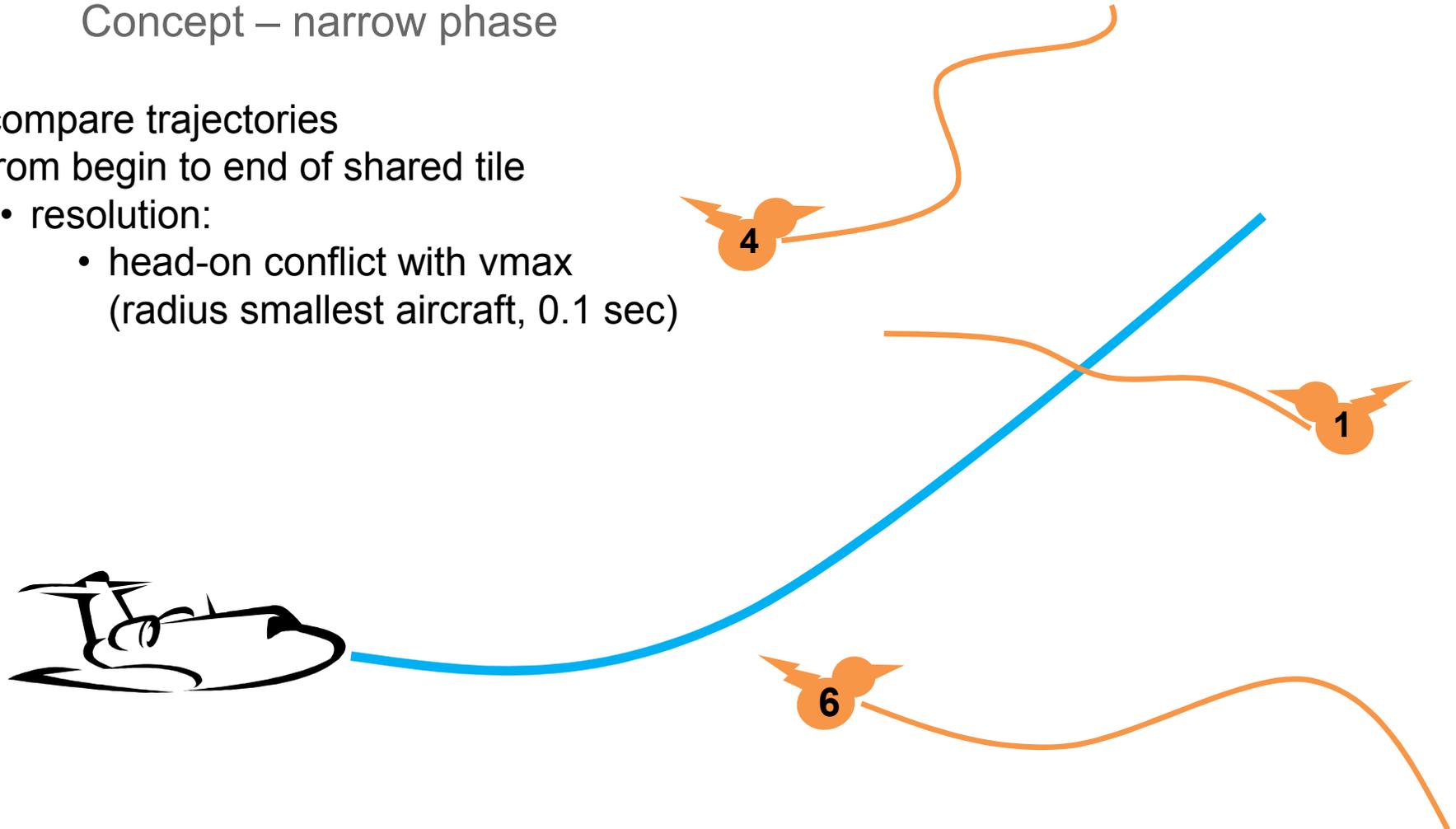
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Collision Avoidance Algorithm

Concept – narrow phase

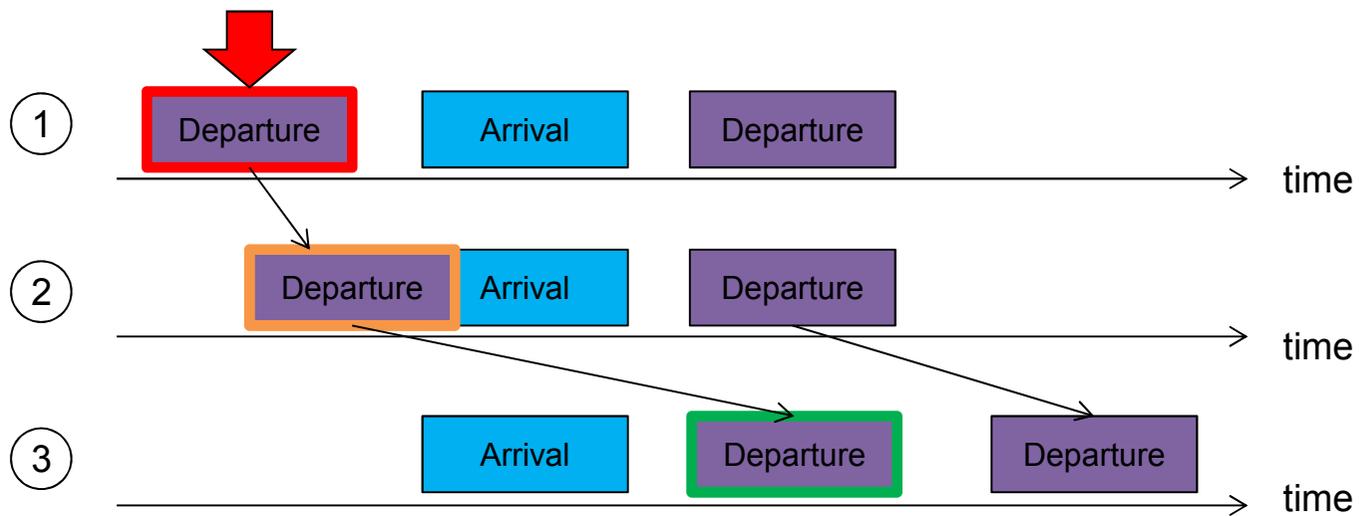
1. compare trajectories
from begin to end of shared tile
 - resolution:
 - head-on conflict with v_{max}
(radius smallest aircraft, 0.1 sec)



Collision Avoidance Algorithm

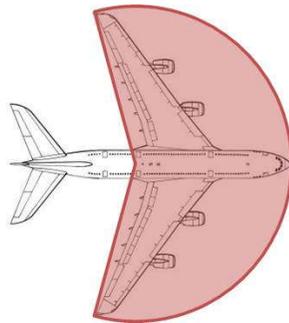
Concept – Conflict Resolution

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



Simulation Specifications

- protected zones birds and aircraft



source: Metz, et al. 2017



Simulation Specifications

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

intensity	number of flights	opening hours
high	954	17 hours
medium	501	
low	305	



Results

- how many bird strikes can be prevented?
- how many false alerts are generated?

verification

- how much delay is generated?
- what are the economic consequences?

SAFETY
CAPACITY

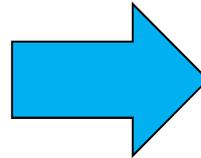


Results

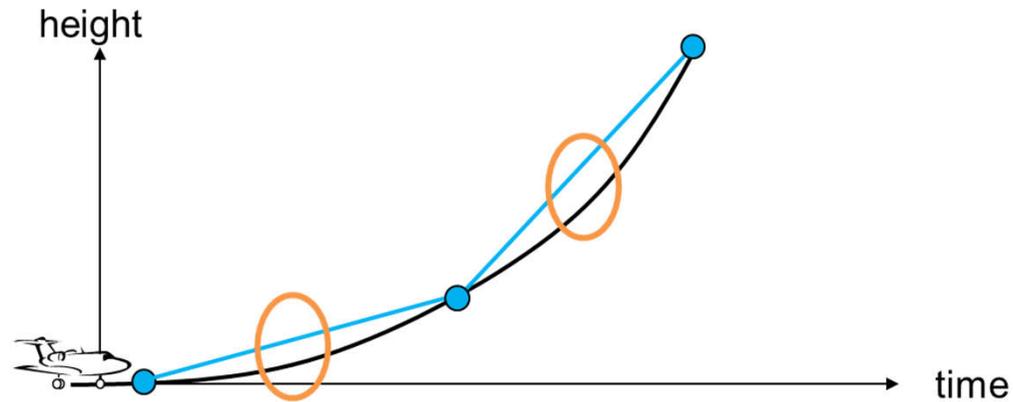
Verification

- Criteria

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

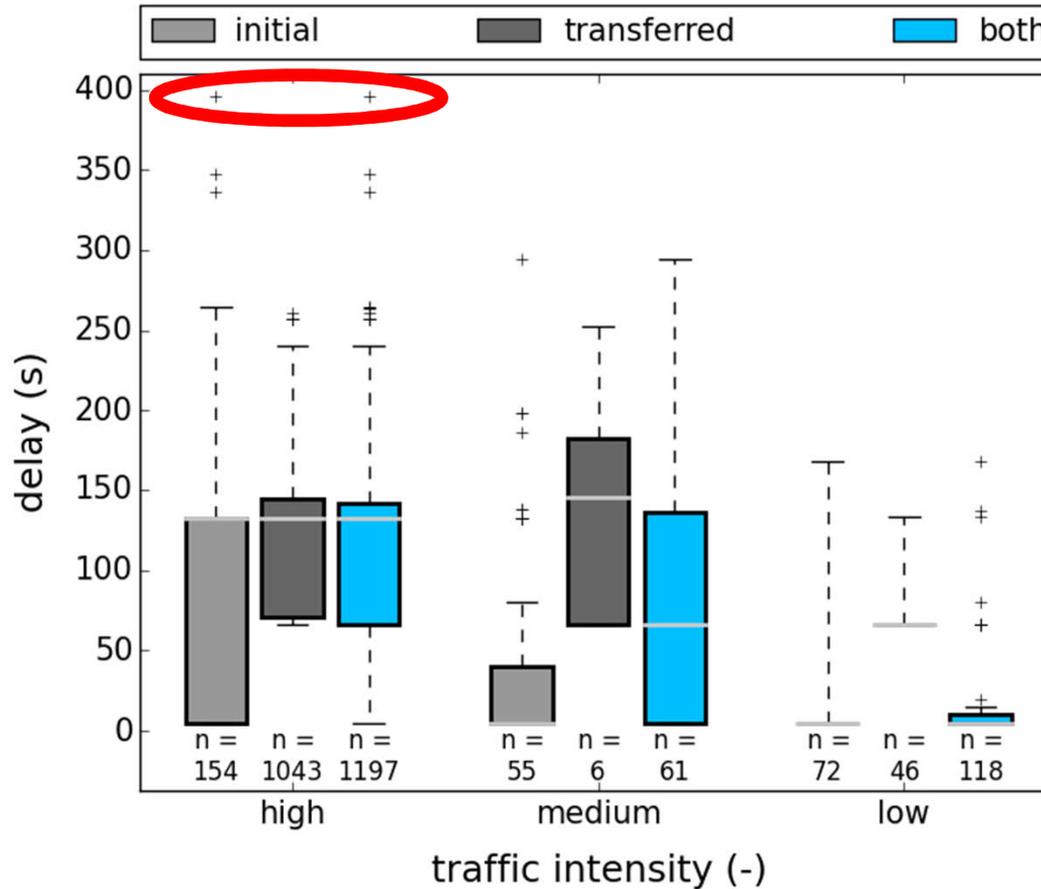


97 % prevented strikes (360/369)
2 % false warnings (6/369)



Results

generated delays



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

Results

economic consequences

- assumptions

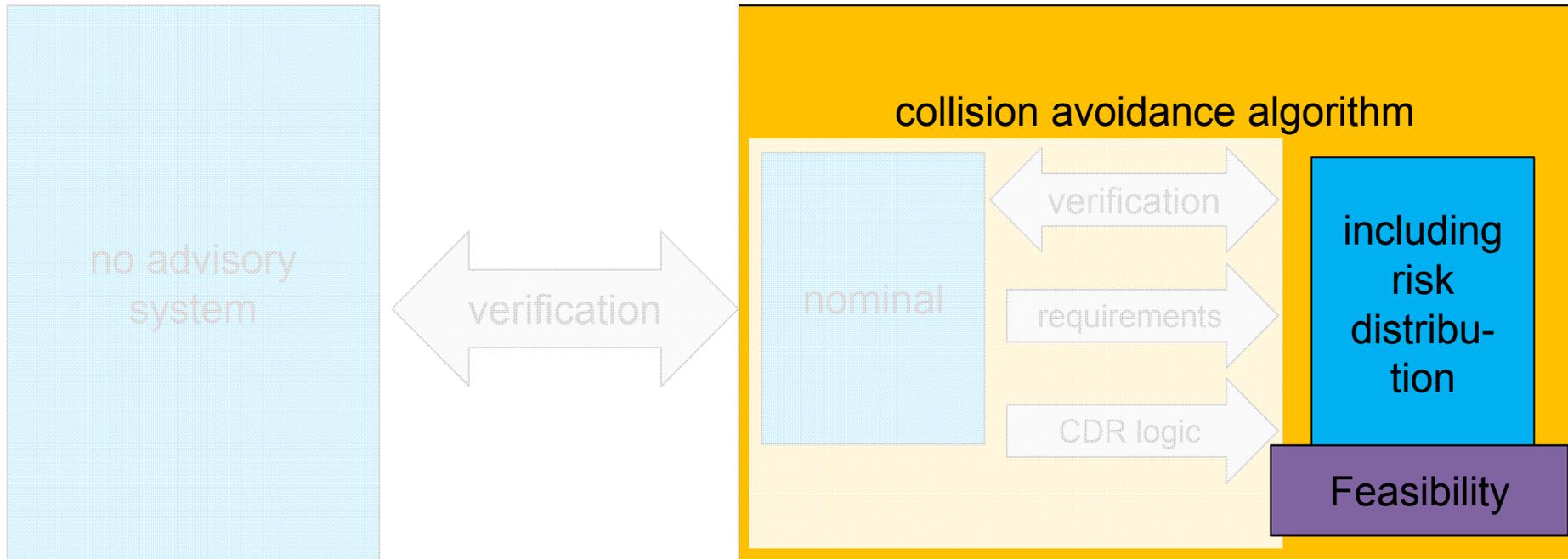
cost per bird strike: €24.947 (FAA)

cost per delay minute : €35 (University of Westminster)

traffic intensity	prevented bird strikes	saved costs	sum delay minutes	delay costs	saved costs per caused costs
high	149	3,717,103	2,455	85,925	43
medium	68	1,696,396	150	5,239	324
low	53	1,322,191	19	676	1957



Approach



Collision Avoidance Algorithm

Including Risk Distribution

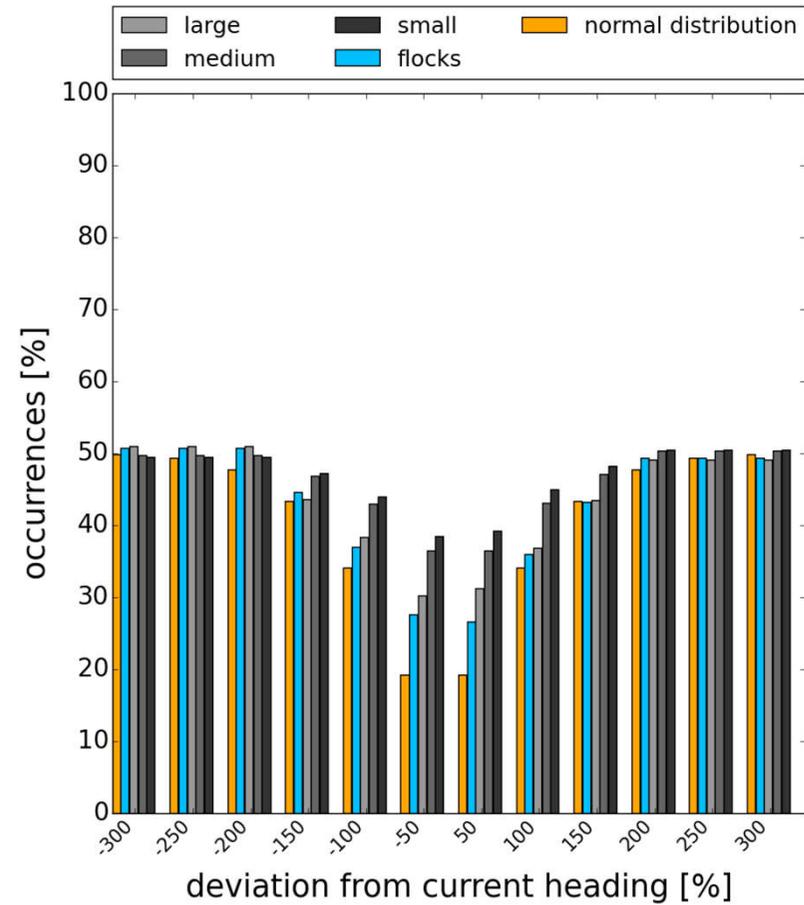
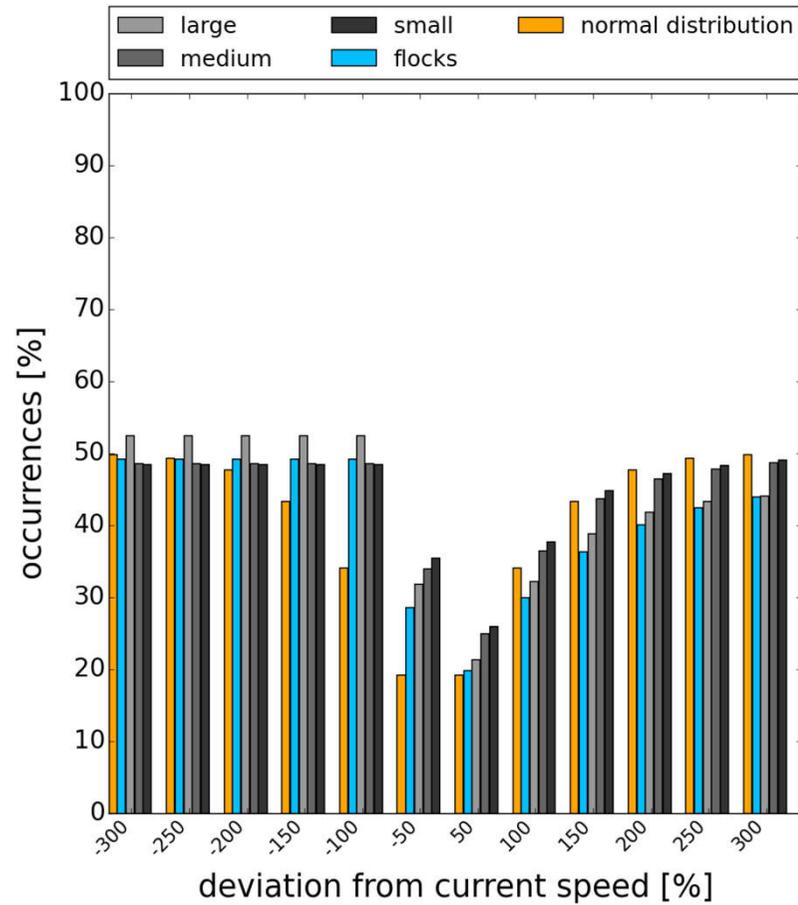
how predictable is bird movement?



variation in speed and heading



Collision Avoidance Algorithm Including Risk Distribution

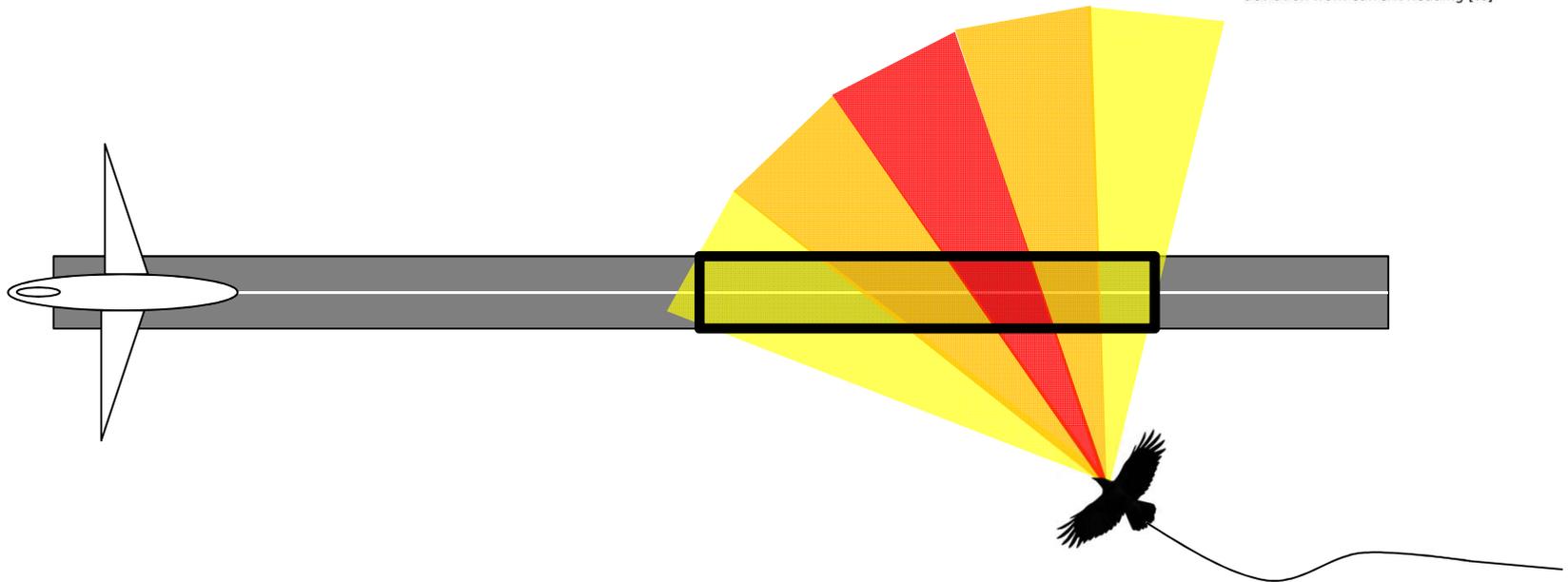
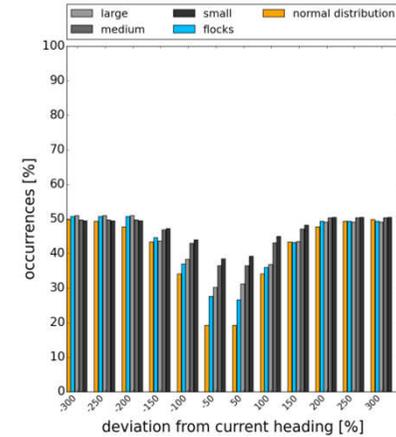


Collision Avoidance Algorithm

Including Risk Distribution

Risk is a function of

- probability speed * probability heading
 - kinetic energy
- risk of damage



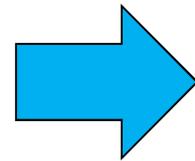
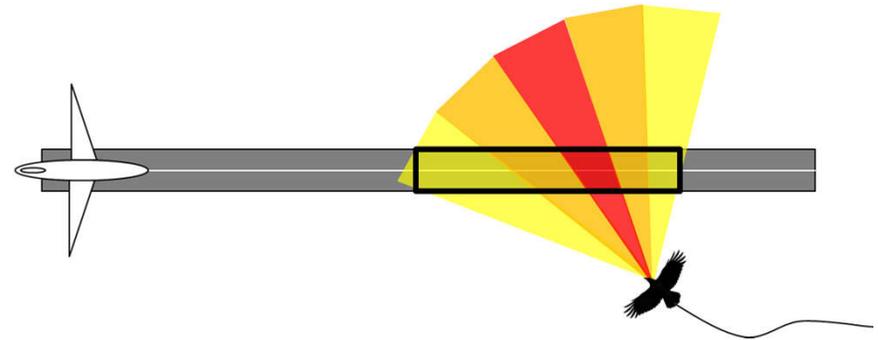
Summary and Outlook

- simulation environment
 - reproducible number of strikes
 - seasonal correspondence
- deterministic collision avoidance algorithm
 - 97 % prevented strikes
 - 2 % false warnings
 - very limited impact on capacity
 - high potential for cost reduction



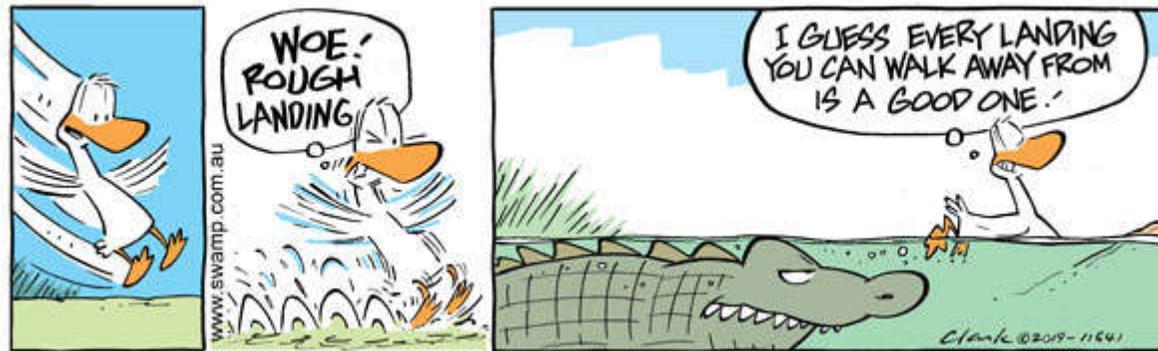
Summary and Outlook

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next step:
including uncertainty
in bird movements

Thank
you!



Questions?

