

Safety Optimization of a Layered Airspace Structure with Supervised Learning

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Presentation Structure

Introduction

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Methodology

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- Training
- Testing

Conclusions & Future Work

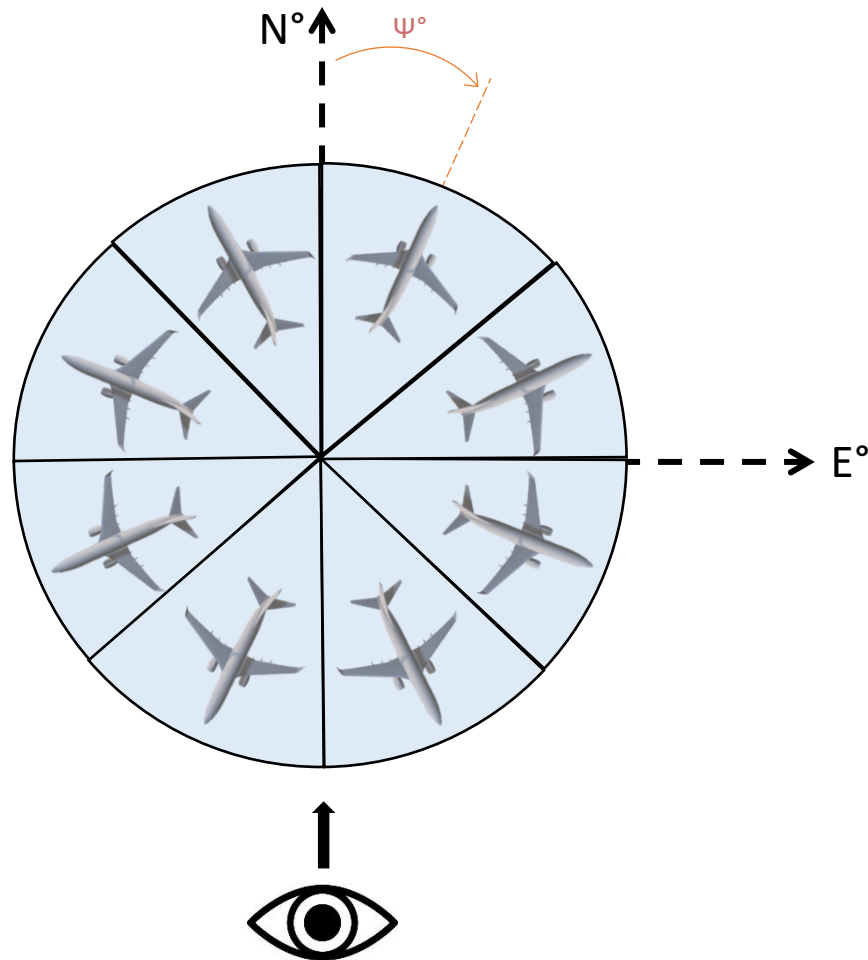
Introduction

- Expected urban airspace traffic densities see many high-frequency coordination challenges
- Existing research [1], advocates that higher traffic densities can be achieved through a reduction of current traffic flow constraints
- This was also found in Metropolis [2]; comparison of 4 urban airspace architectures

[1] J. Hoekstra, R. van Gent, and R. Ruigrok, "Designing for safety: the 'free flight' air traffic management concept" 2002

[2] E. Sunil, J. Hoekstra, J. Ellerbroek et al., "Metropolis", 2015

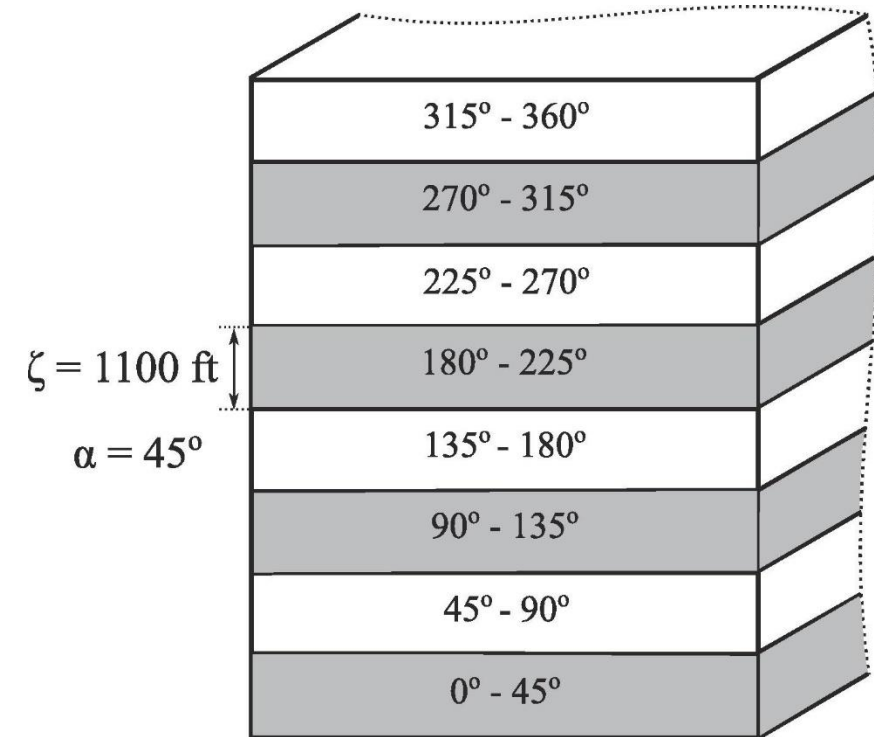
Background – Layered Airspace



[2] E. Sunil, J. Hoekstra, J. Ellerbroek et al., "Metropolis", 2015

Background – Layered Airspace

- Segmentation: default vertical separation
- Alignment: decrease in relative speeds decreases conflict rate [2]

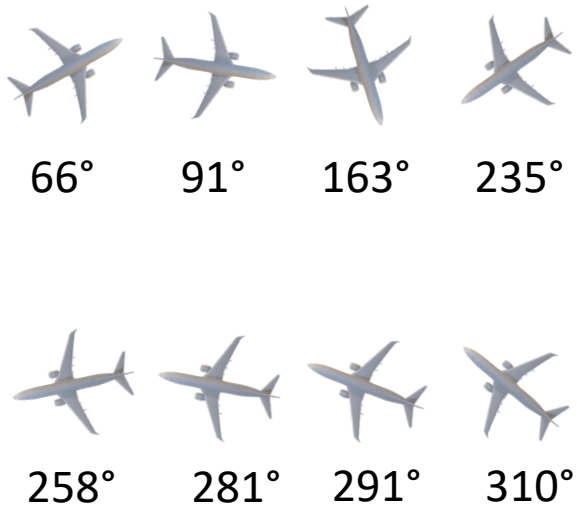


[2] E. Sunil, J. Hoekstra, J. Ellerbroek et al., “Metropolis”, 2015

[3] E. Sunil, , J. Ellerbroek, J. Hoekstra J. Maas. “Three-dimensional conflict count models for ustructured and layered airspace designs”, 2015

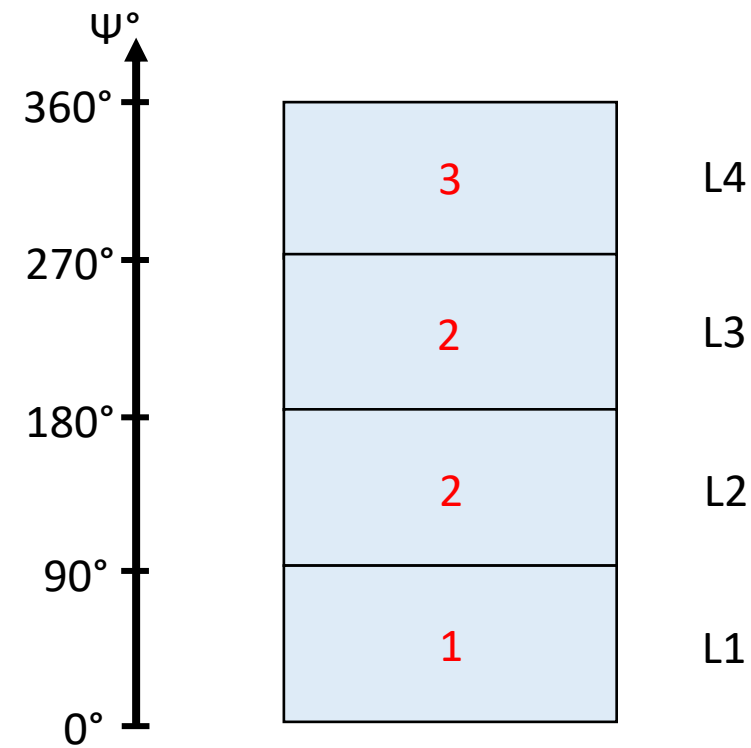
Background – Evenly Distributed Layers (1)

Uniformly Distributed Heading



&

Evenly Distributed Layers

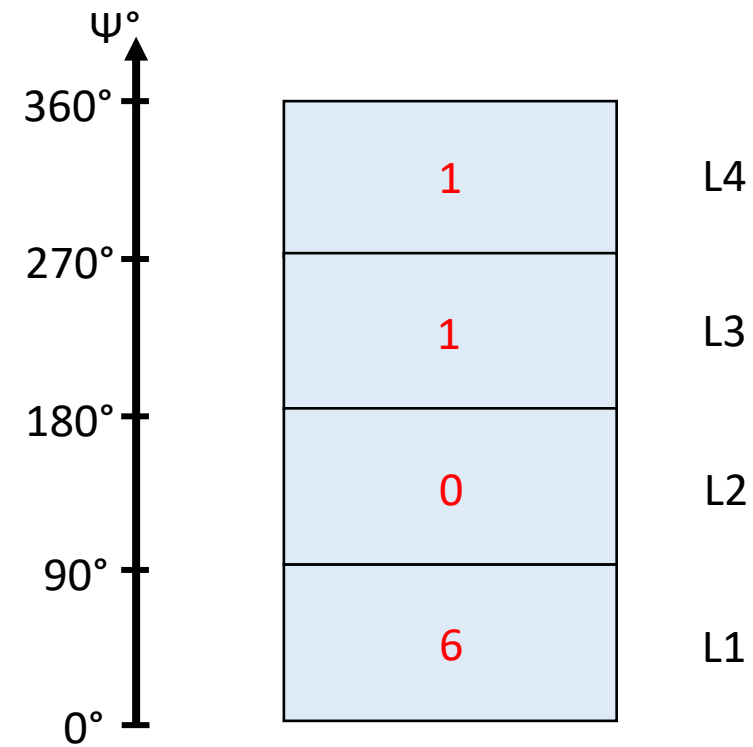
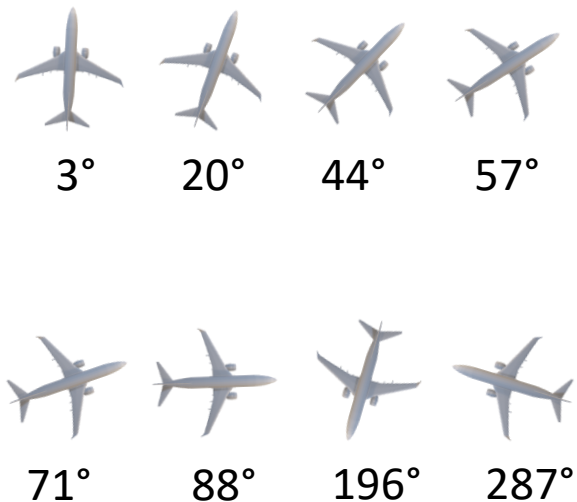


Background – Evenly Distributed Layers (2)

Non - Uniformly Distributed Heading

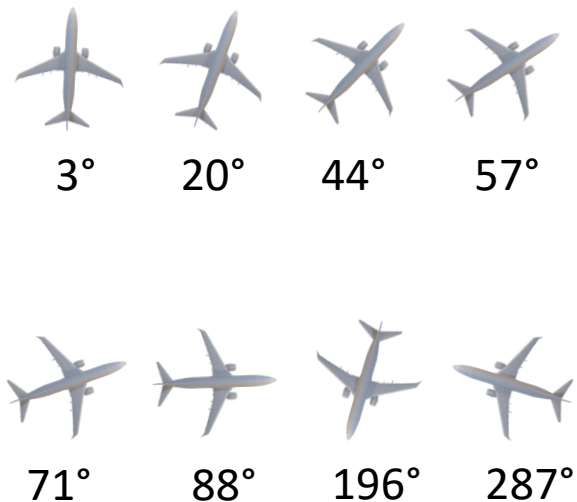
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Evenly Distributed Layers



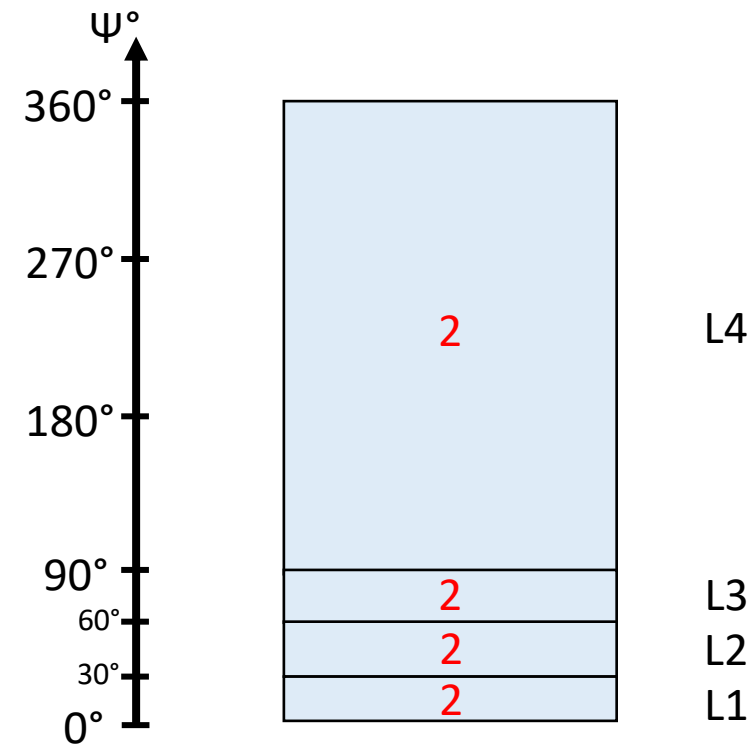
Background – Evenly Distributed Layers (3)

Non - Uniformly Distributed Heading



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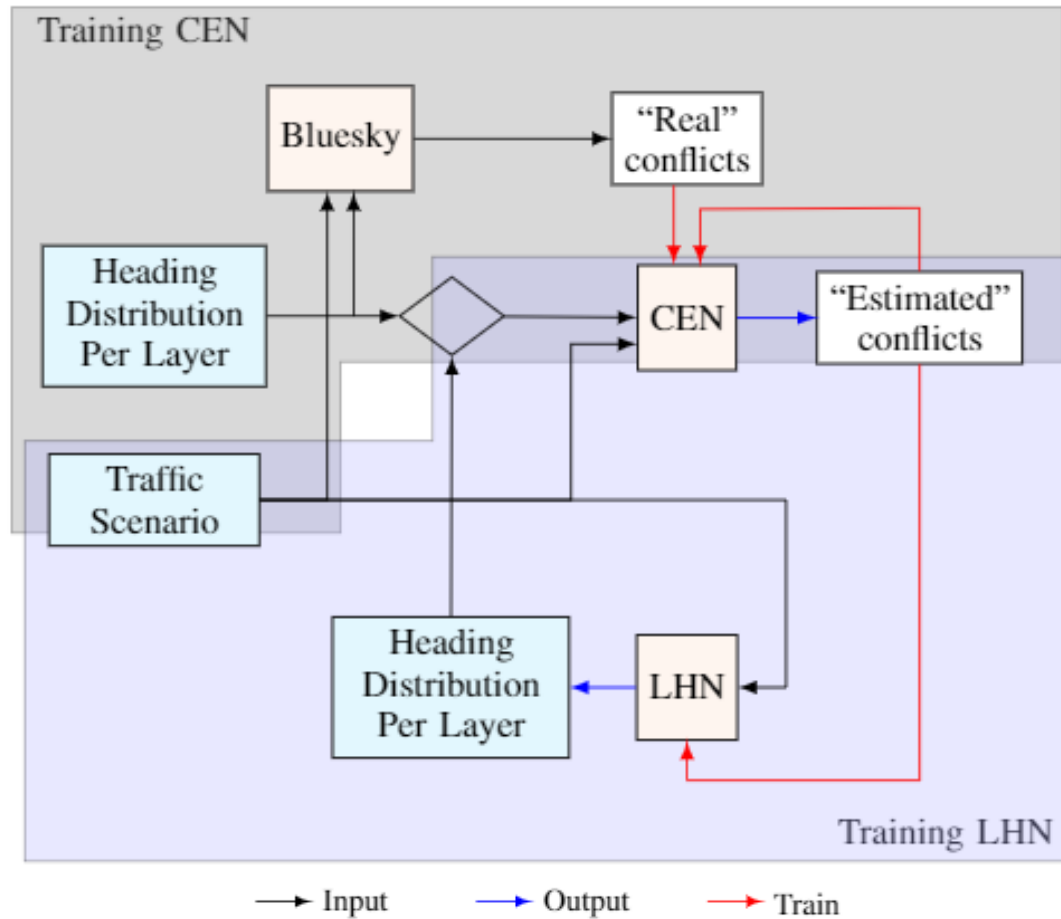
Unevenly Distributed Layers



Problem Formulation

*“Given a set of aircraft within a layered airspace,
find the optimal layer assignment which
minimizes the number of conflicts”*

Methods – Supervised Learning



Conflict
Estimator
Network

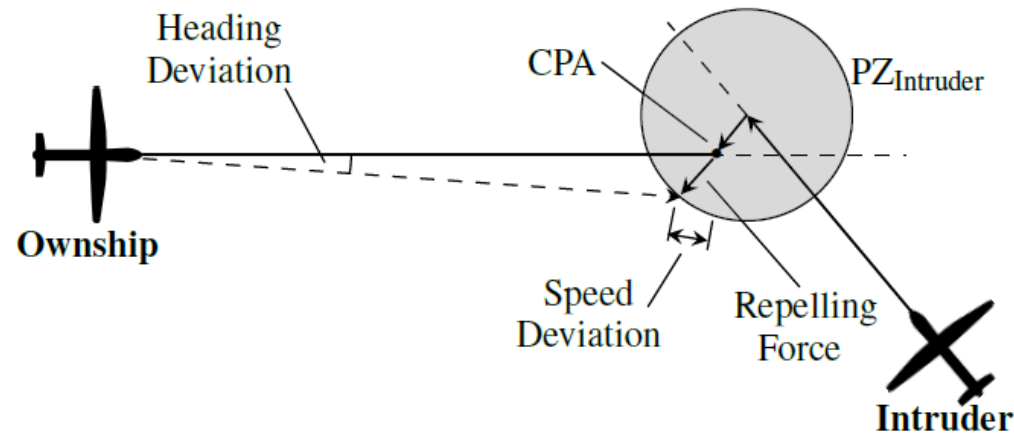
Goal: Estimate number of conflicts given traffic scenario

Layer
Heading
Network

Goal: Assign aircraft to layers while minimizing the number of conflicts

Methods – Conflict Resolution (CR)

Geometric Conflict Resolution Method: Model Voltage Potential (MVP)



MVP resolution advisory based on geometry at Closest Point of Approach (CPA) [4]

[4] J. M. Hoekstra, "Free flight in a crowded airspace?" 2000.

▼ AC0001
FL100
300

◀ AC0002
FL200
400

▲ AC0002
FL100
300

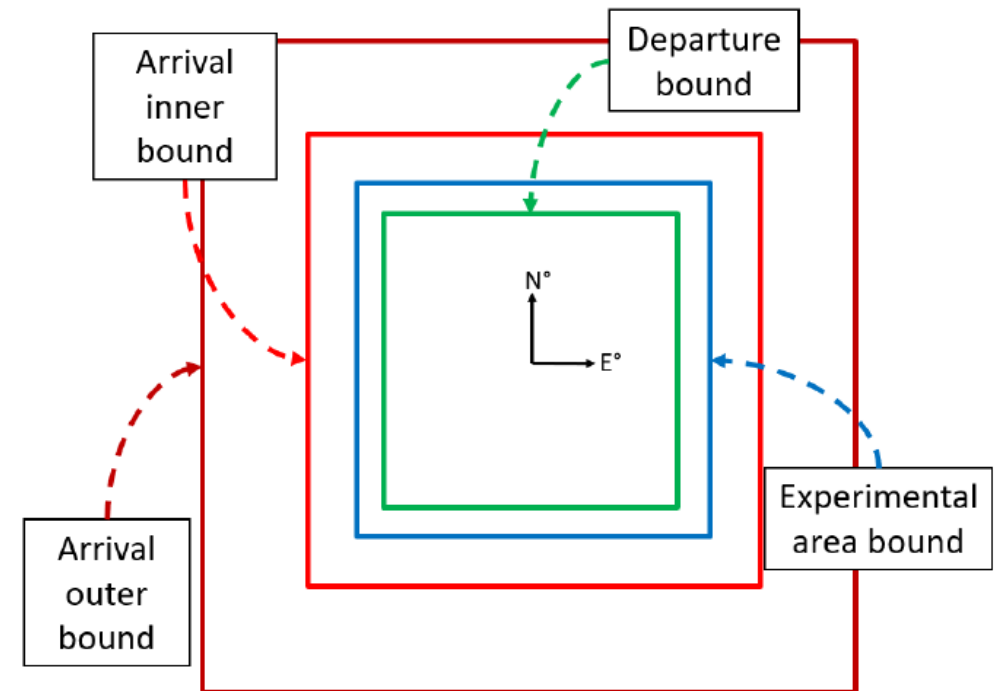
▲ AC0001
FL200
400



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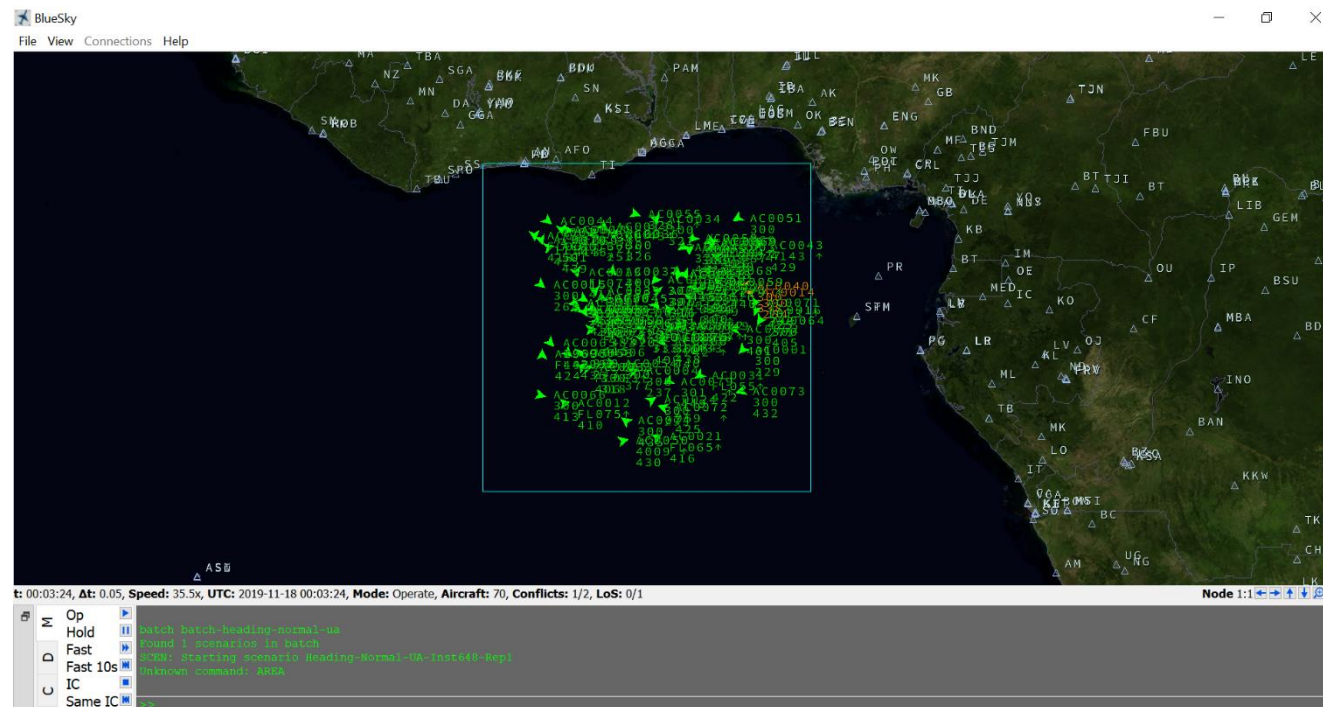
Methods – Training Environment

	CEN	LHN
Loss	MSE (actual conflicts, est. conflicts)	Number of estimated conflicts
Number of aircraft	100	100
Number of layers	8	8



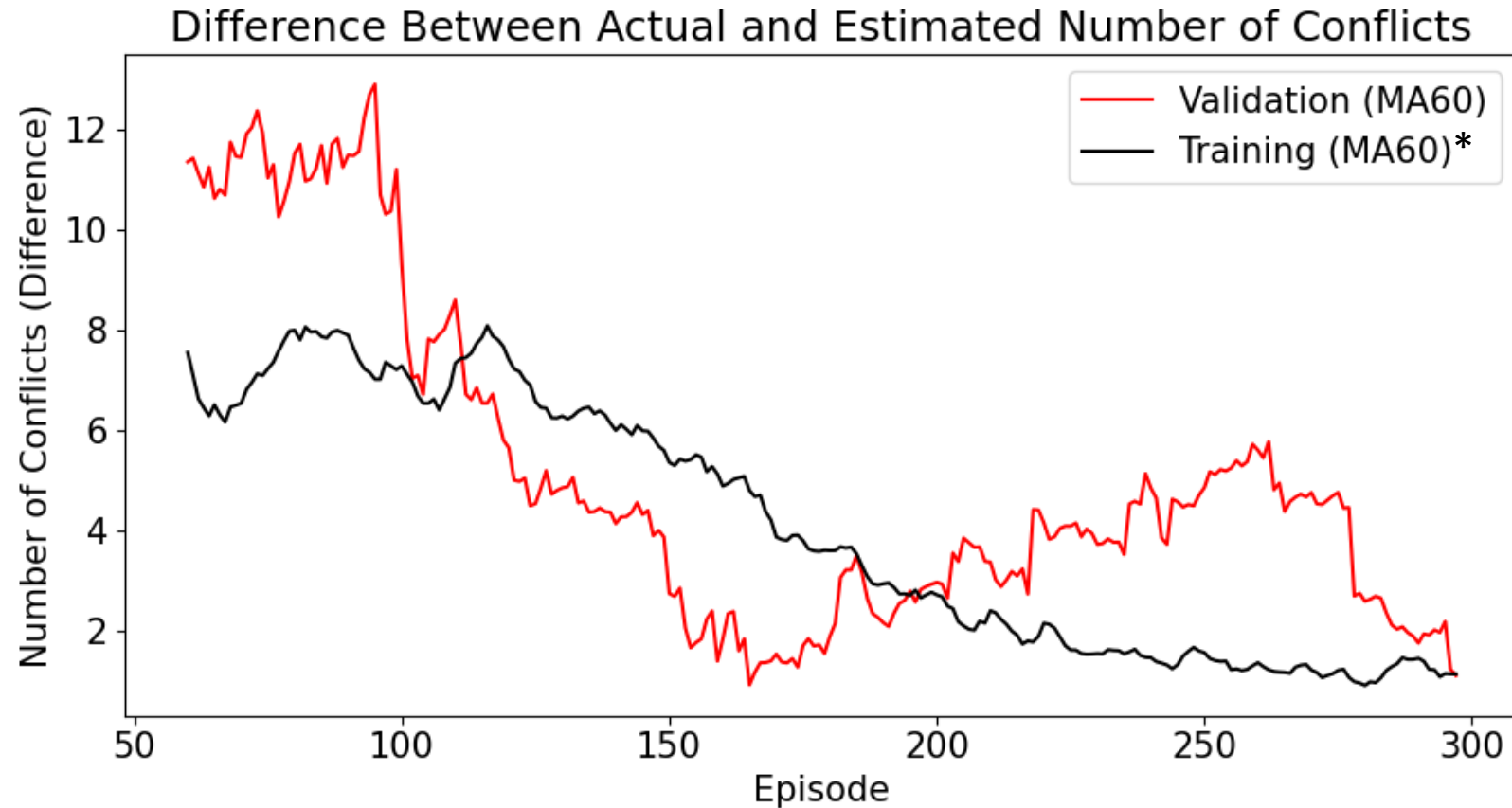
Methods – Training Environment

BlueSky - The Open Air Traffic Simulator [5]



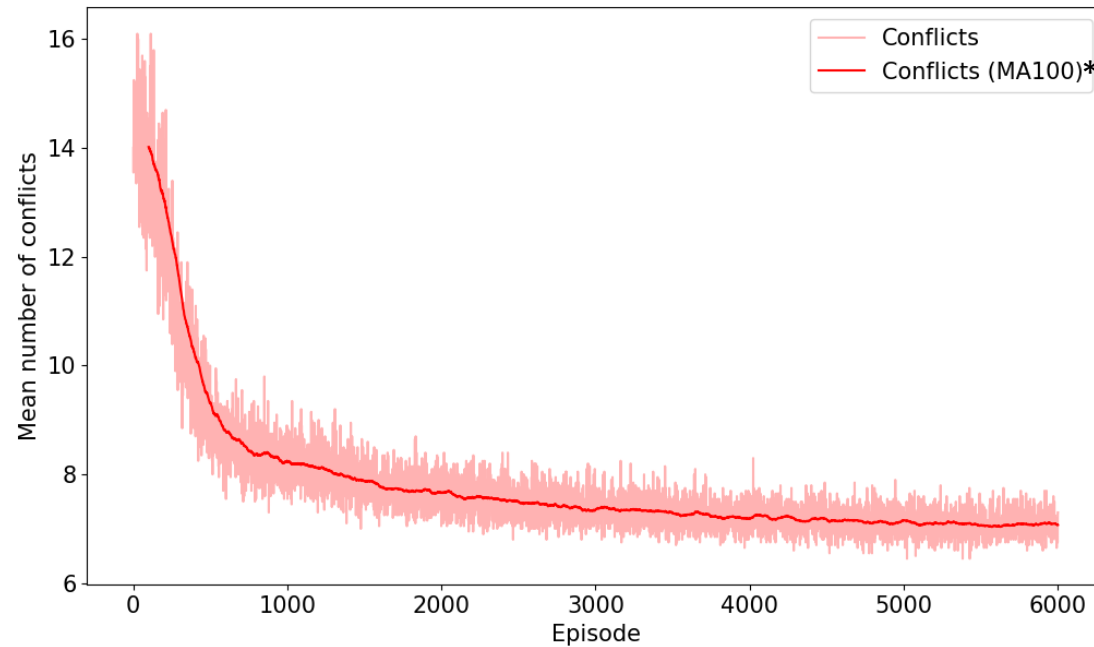
[5] <https://github.com/TUDelft-CNS-ATM/bluesky>

Results – CEN Training

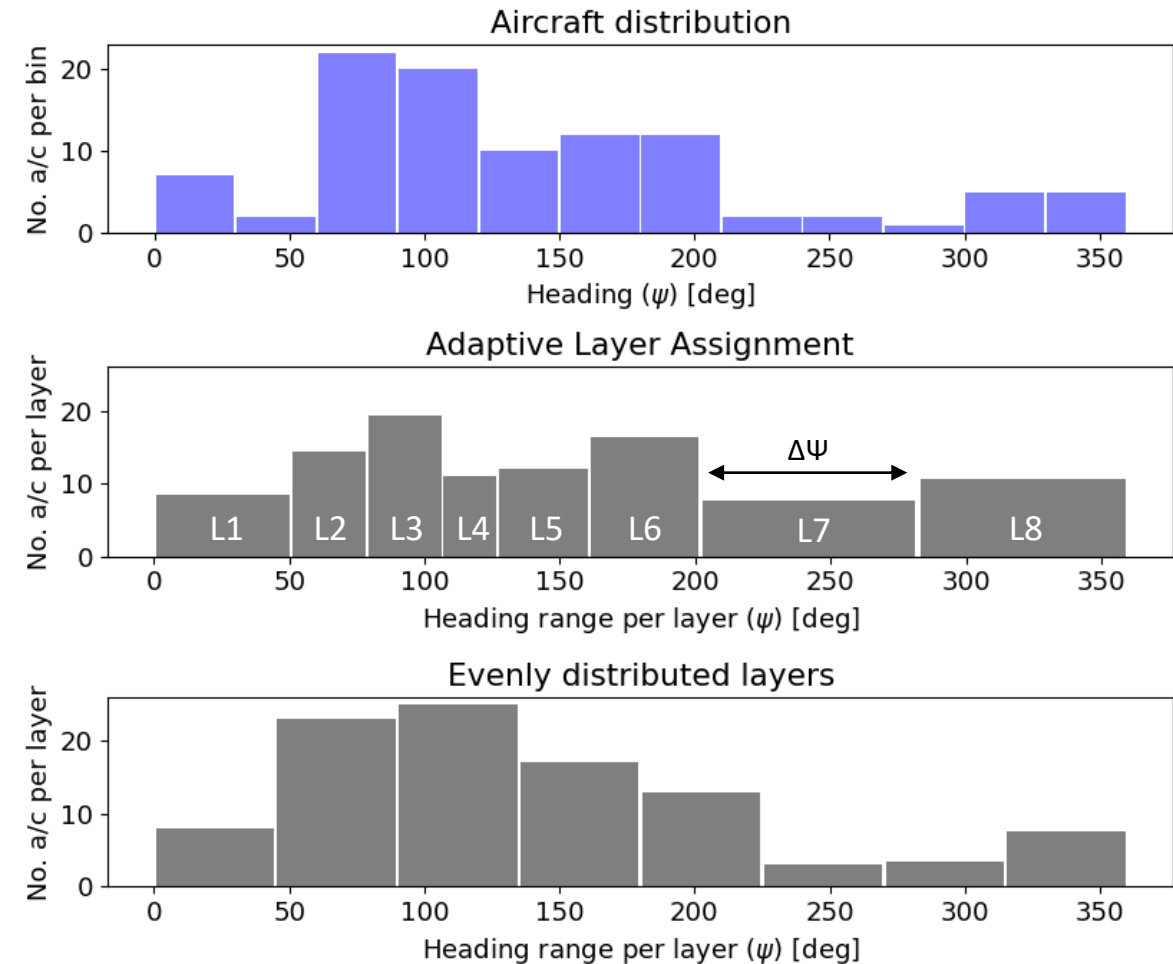


* MA60 = 60-episode moving average

Results – LHN Training

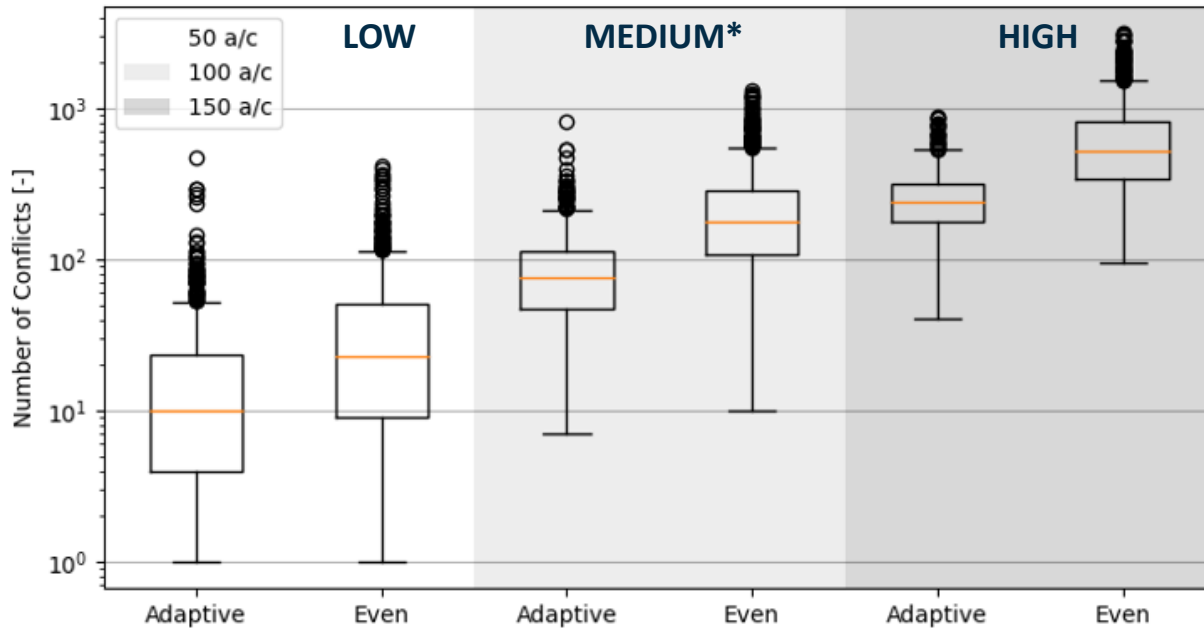


* MA100 = 100-episode moving average

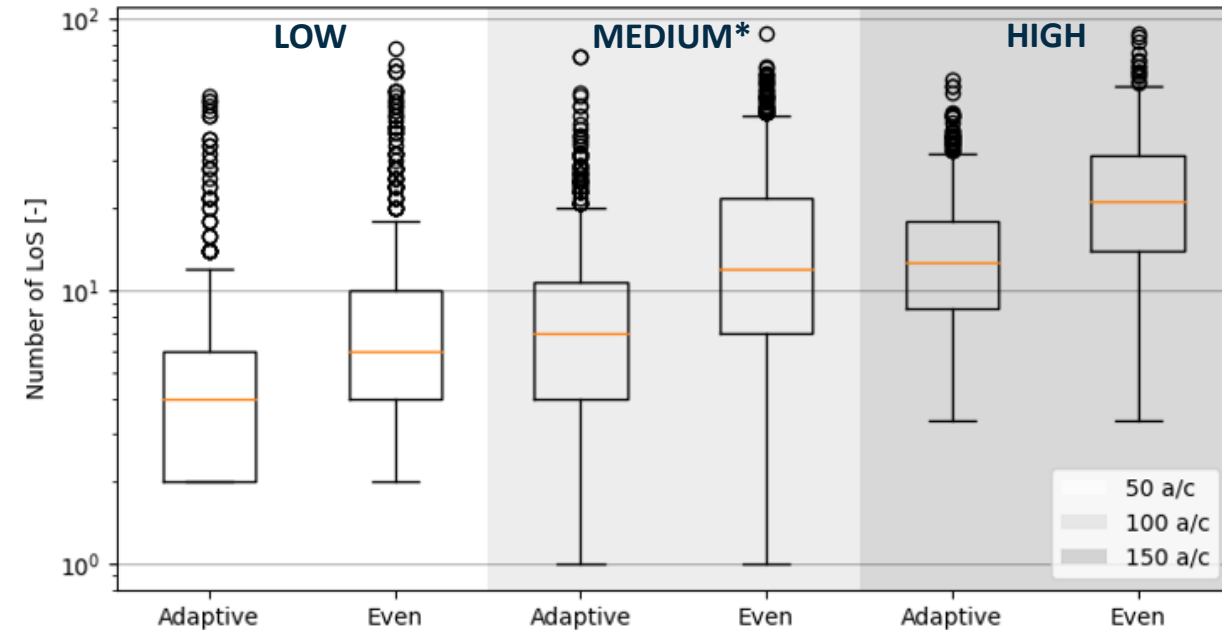


Results – Testing: Safety (1)

Conflicts



Losses of Separation

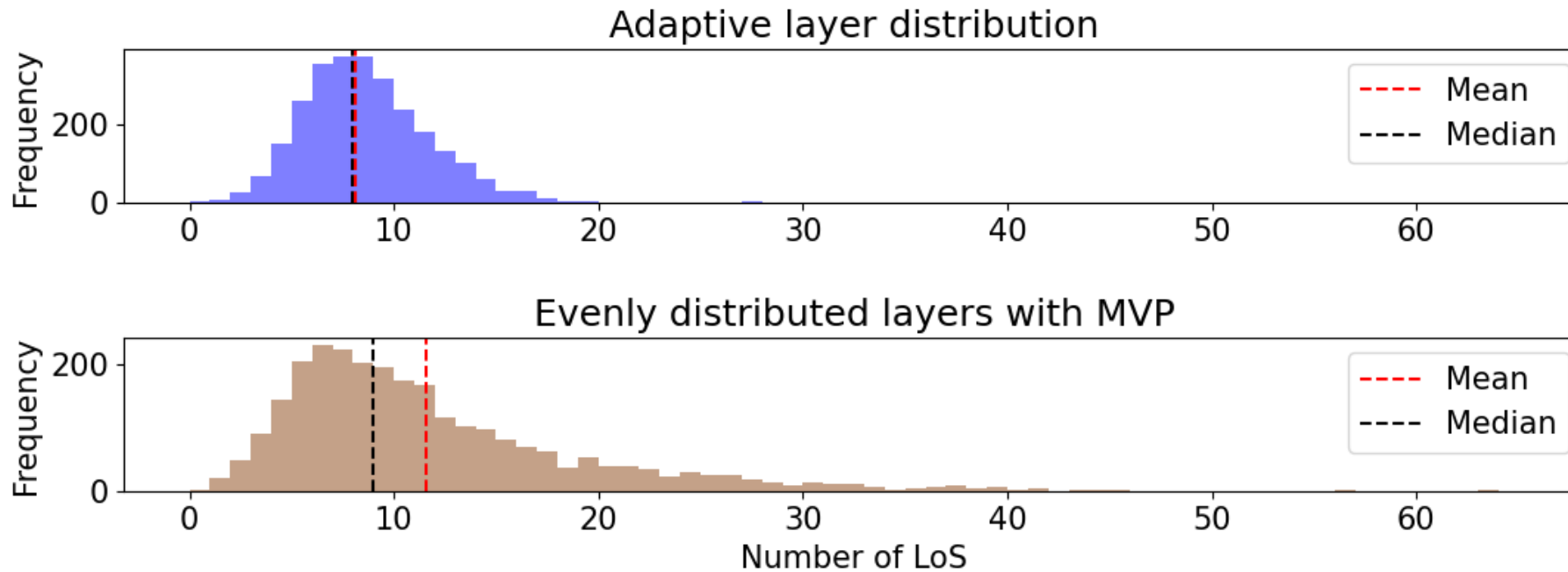


*same as training

Results – Testing: Safety (2)

Losses of Separation

(2715 episodes,
medium demand)

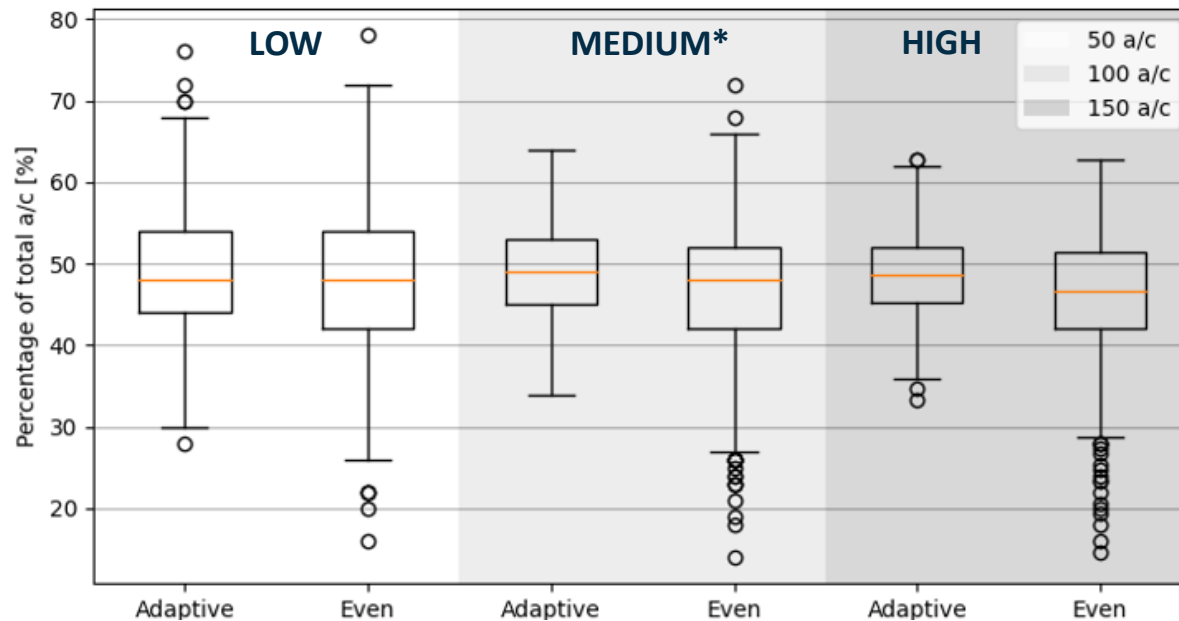


without Conflict Resolution

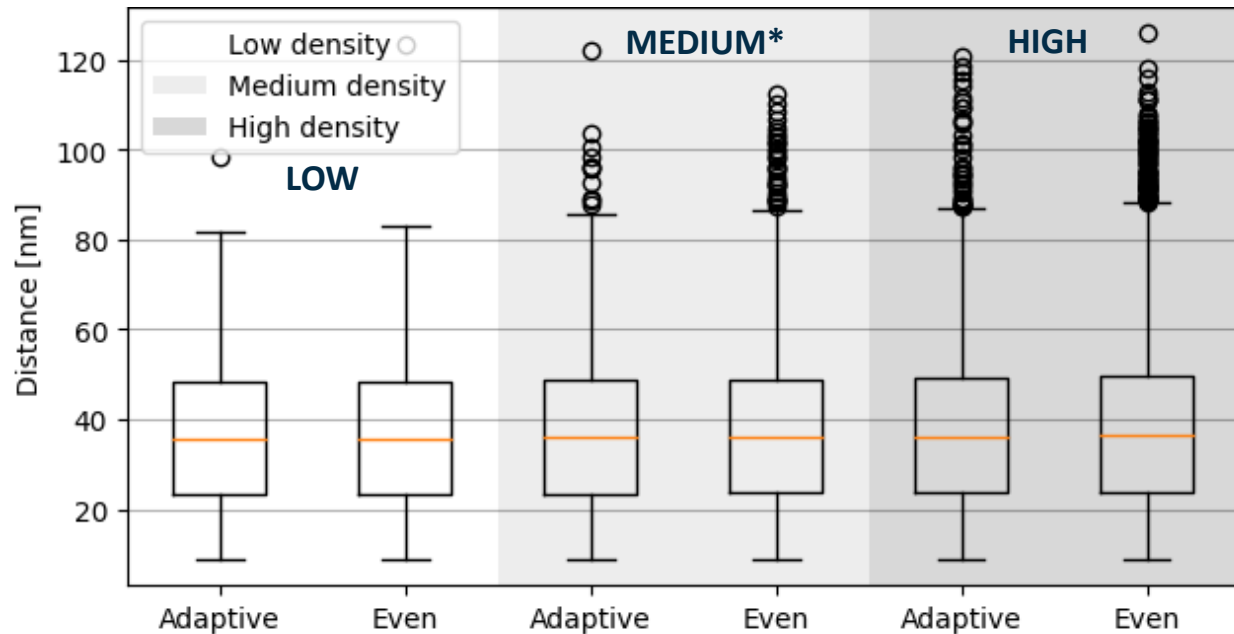
with Conflict Resolution

Results – Testing: Efficiency

Landings



Total distance

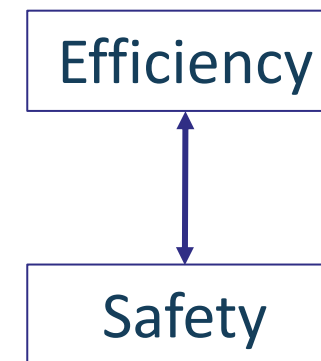
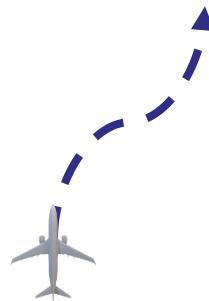
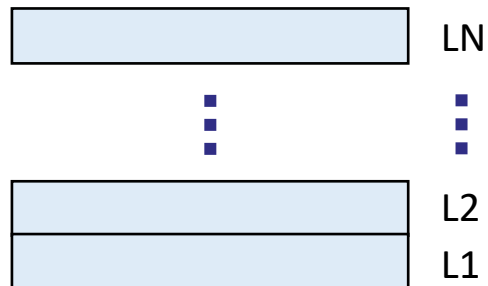


*same as training

Conclusions

- Machine learning is a valid method to analyze the emergent behavior of an environment
- Airspace structure can lower conflicts, but very dependent on traffic demand. Supervised learning can aid this adaption.
- Multi-conflict situations are a challenge: prevention can be a solution

Future Work



Questions ?

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