

Limitations of Conflict Prevention and Resolution in Constrained Very Low-Level Urban Airspace

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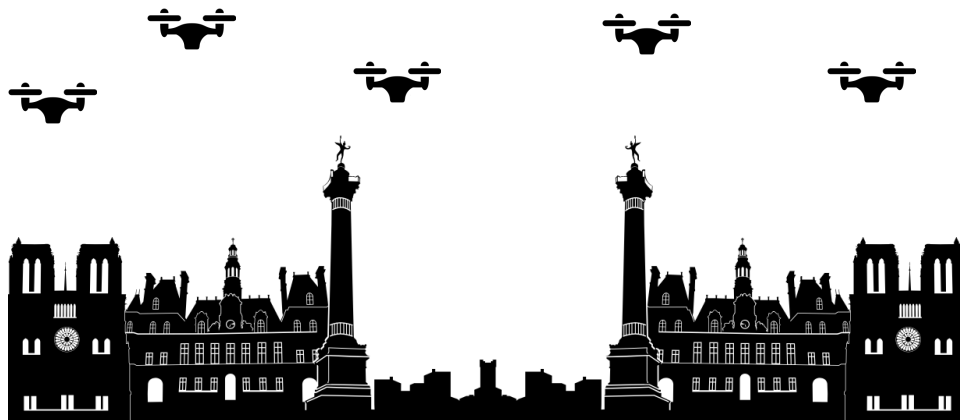
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- Background
- Research Question
- Current Limitations
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- Conclusion

Introduction

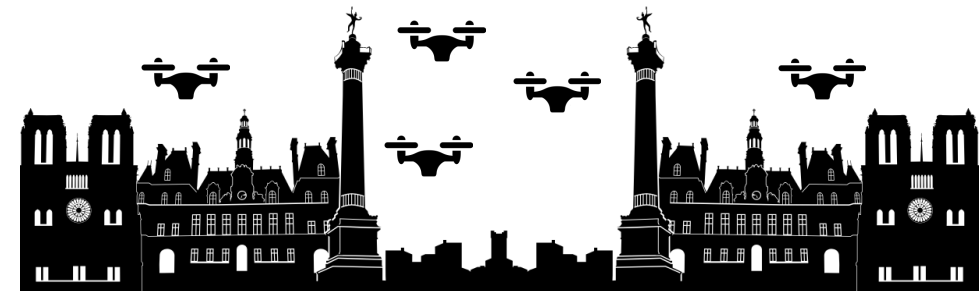
- How should aircraft navigate cities? What are the challenges?
 - Travelling above or between buildings?
 - Should we follow existent road network?
 - Safety with road vehicles is (mostly) guaranteed with different types of lanes. How to apply similar rules with drones?

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Flying Above Buildings

VS

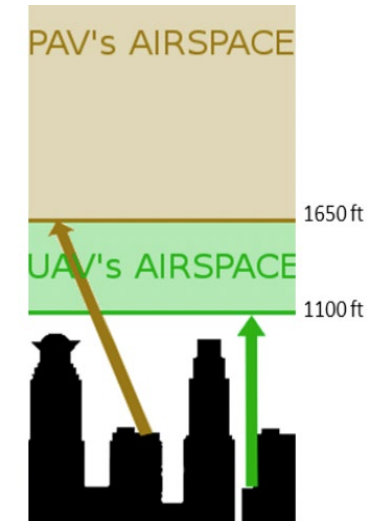


Flying Between Buildings

Background – Metropolis I

Concept:

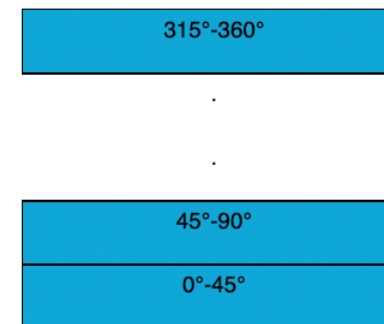
- UAVs and PAVs cruise in dedicated airspace above buildings
- Layered division with heading range
- Linear routes



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Findings:

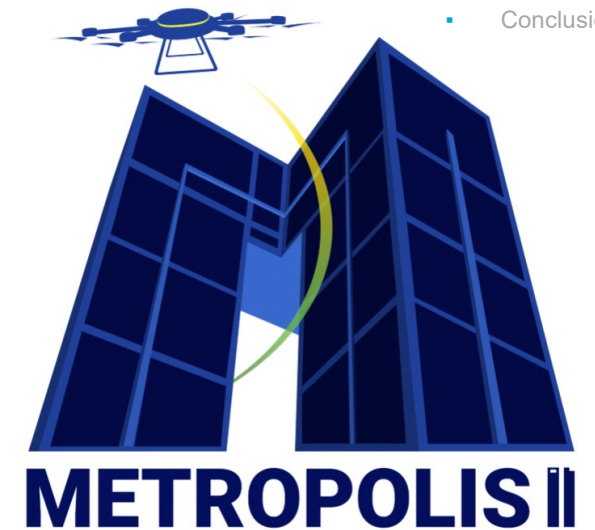
- Alignment
- Segmentation



Background – Metropolis II

- Concept:
 - UAVs cruise between buildings
 - Layered division based on streets
 - Routes need to adjust to surrounding urban infrastructure

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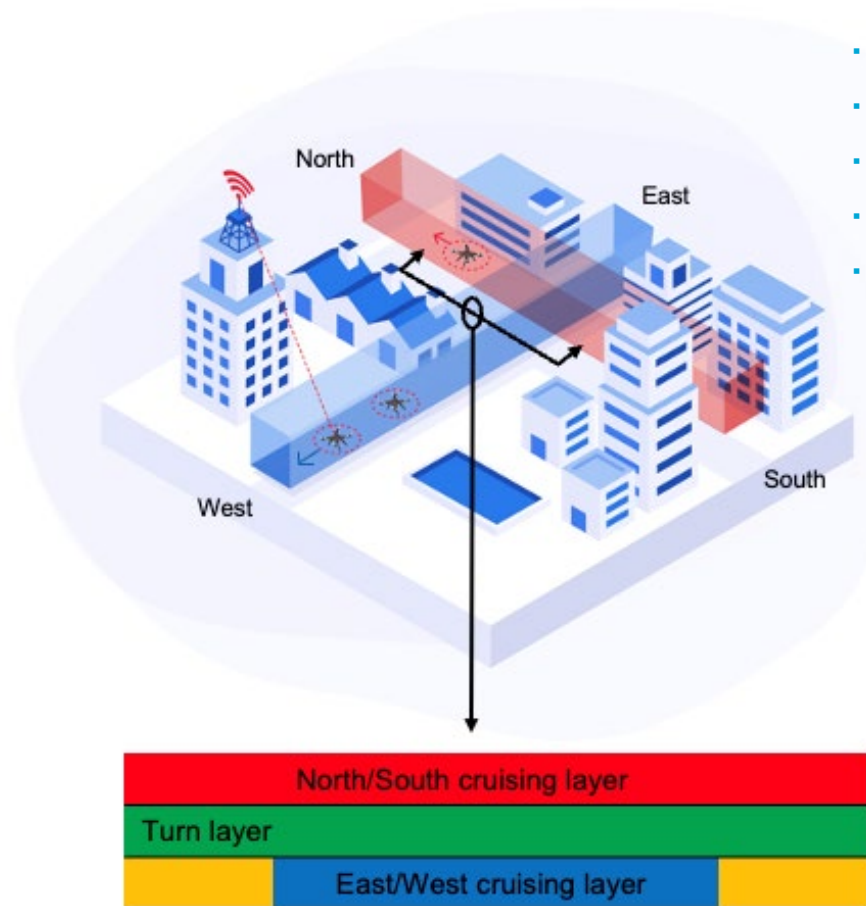
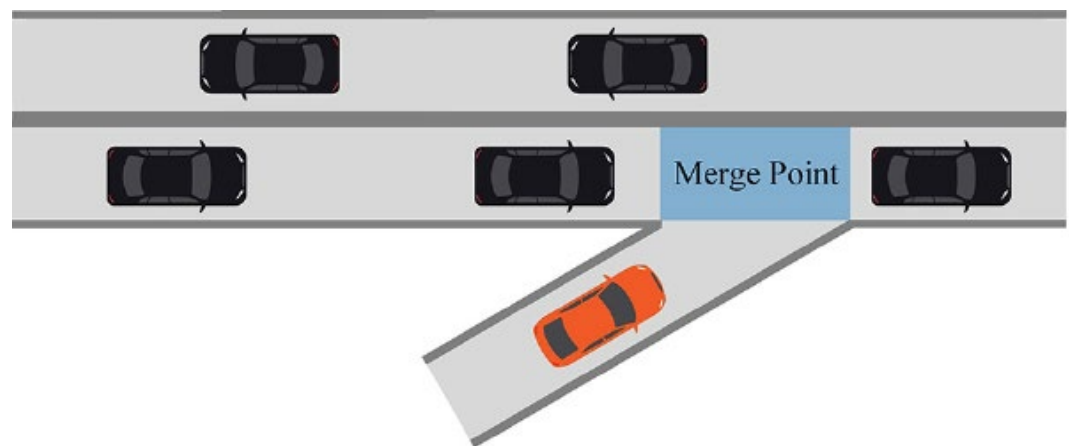
Research Question

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"What are the safety limitations of urban air operations when extending current design towards constrained, in-between buildings airspace?"

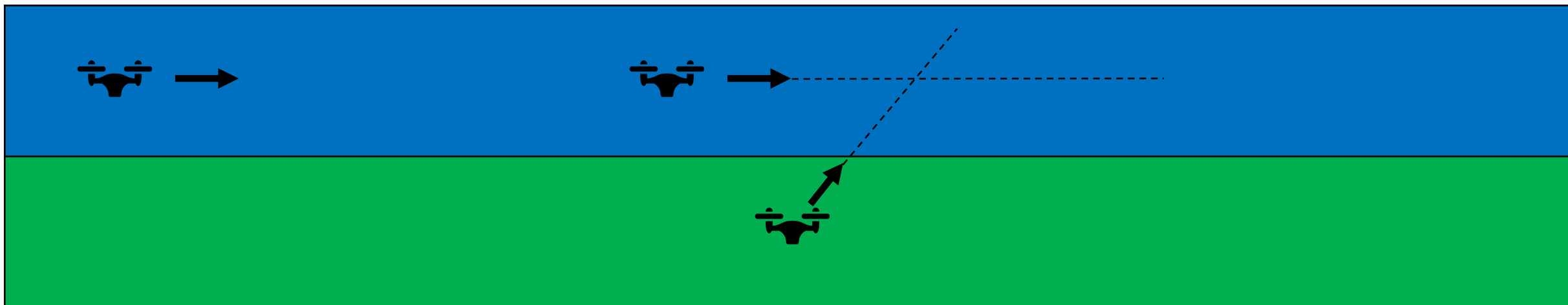
Airspace Structure

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- **Current Limitations**
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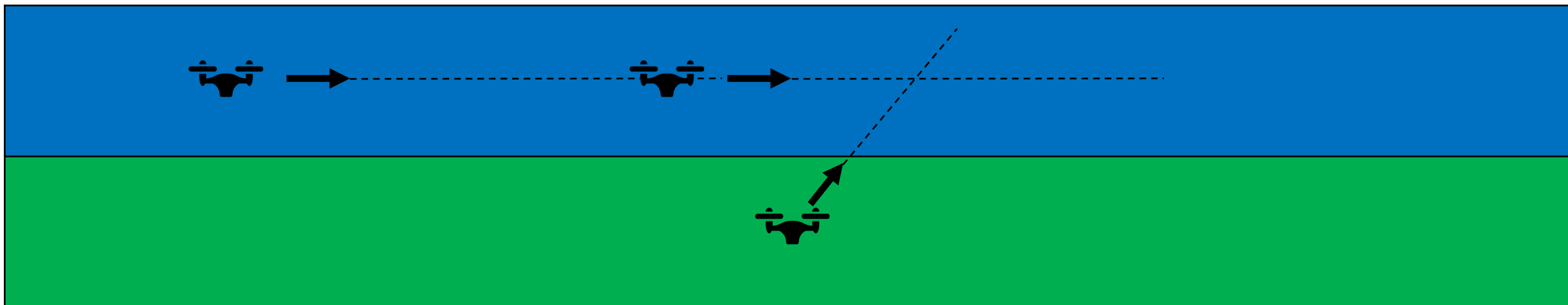
Conflict Resolution

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Conflict Resolution

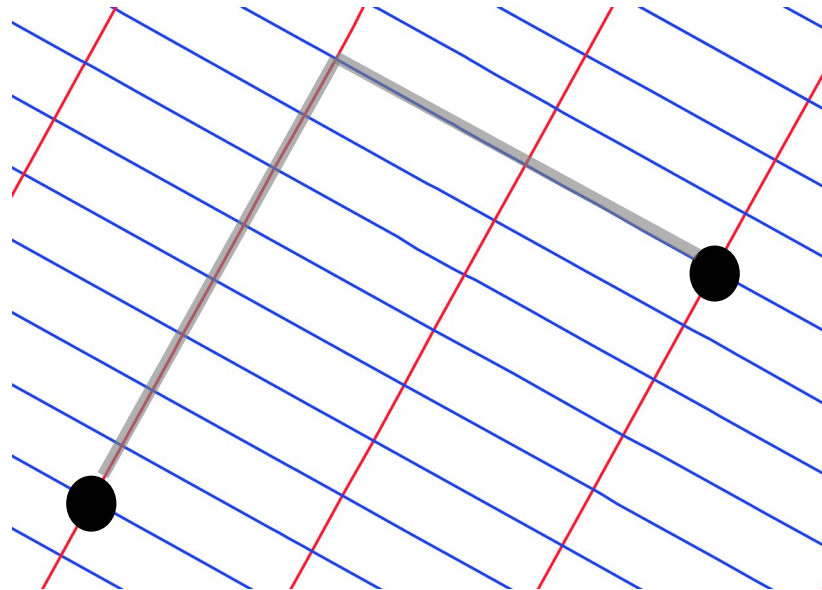
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Flight Planning/Navigation

- Direct routes impossible due to buildings.
- Turns are necessary.
- Certain streets create conflict bottlenecks.

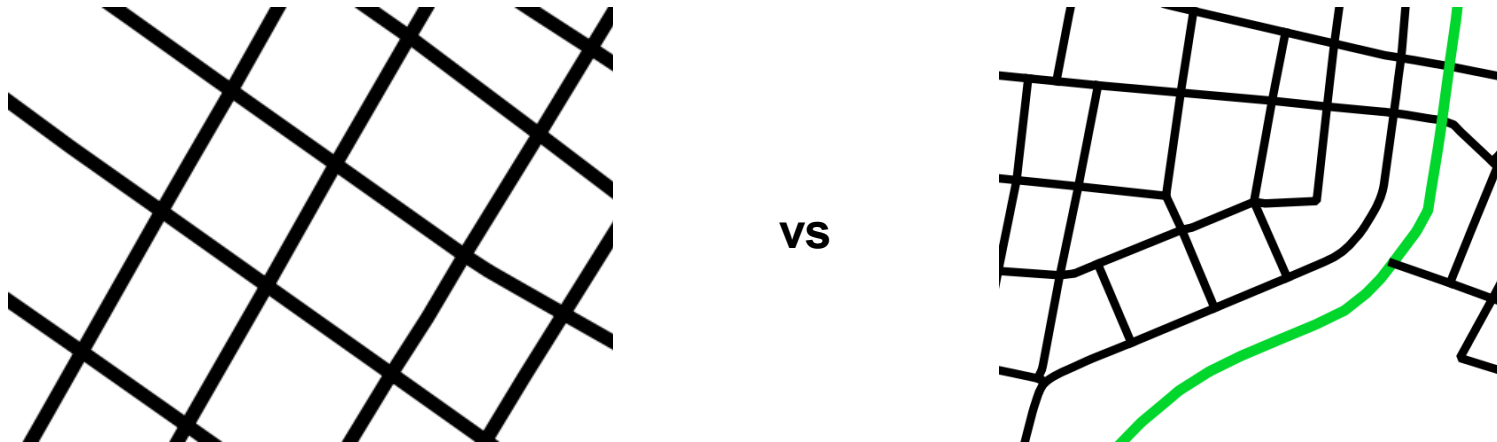
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Non-orthogonal networks

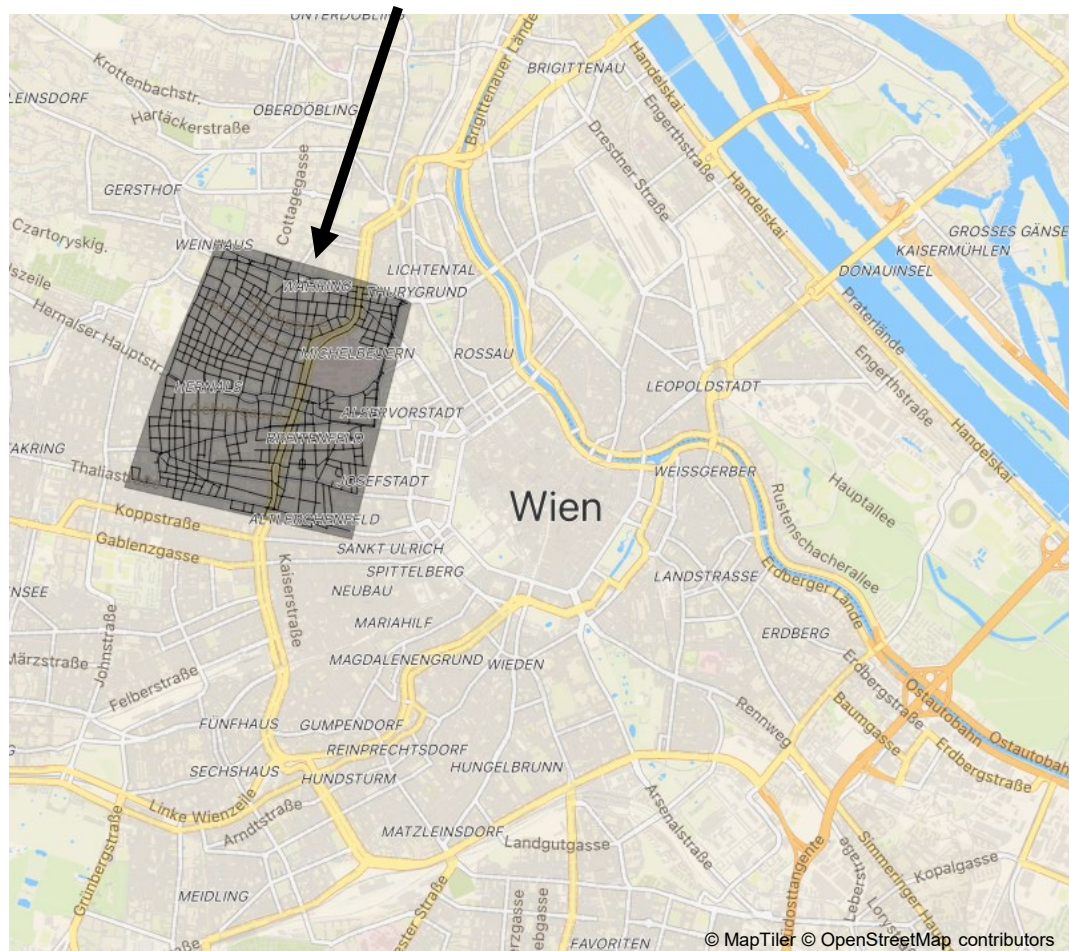
- Non-orthogonal street networks pose more challenges:
 - More turning to reach destination.
 - Intersections will vary so cannot be solved universally.

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Experiment environment

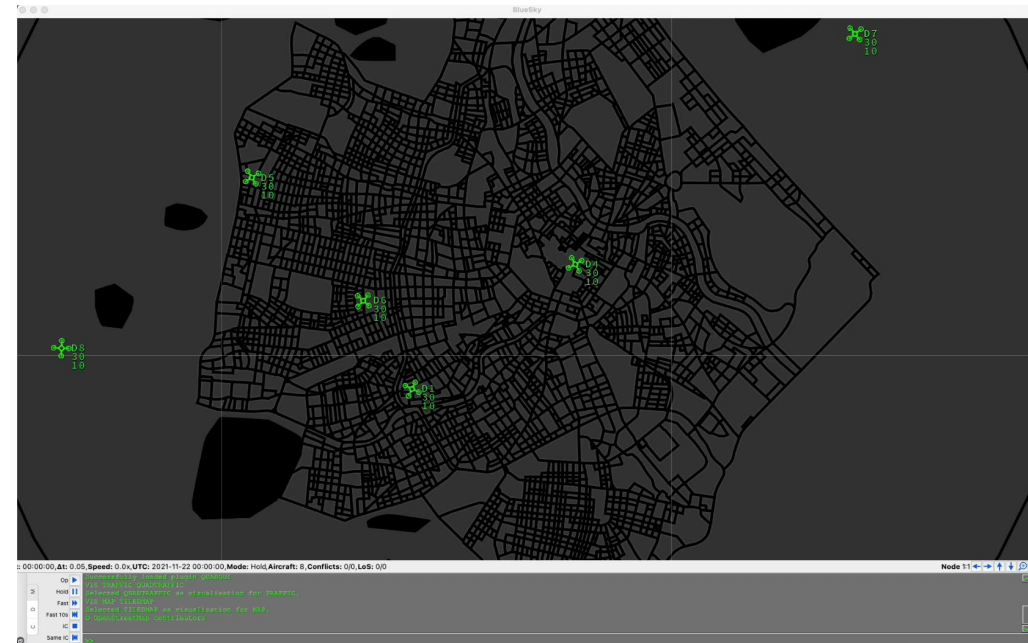
Simulation Area



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Simulation method

- BlueSky Open Air Traffic Control Simulator.
- Used aircraft model based on the DJI Matrice 600 Pro hexacopter.
- GitHub: [TUdelft-CNS-ATM/bluesky](https://github.com/TUdelft-CNS-ATM/bluesky)



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Method

- Independent variables
 1. Use of conflict resolution (speed-based)
 2. One cruising layer vs two cruising layers:



VS



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3. Traffic density:

	Average (rounded)	Peak
Low density (L)	3	5
Medium density (M)	5	8
High density (H)	7	11

Results

Legend:

N: None (CR-OFF + one cruising layer)

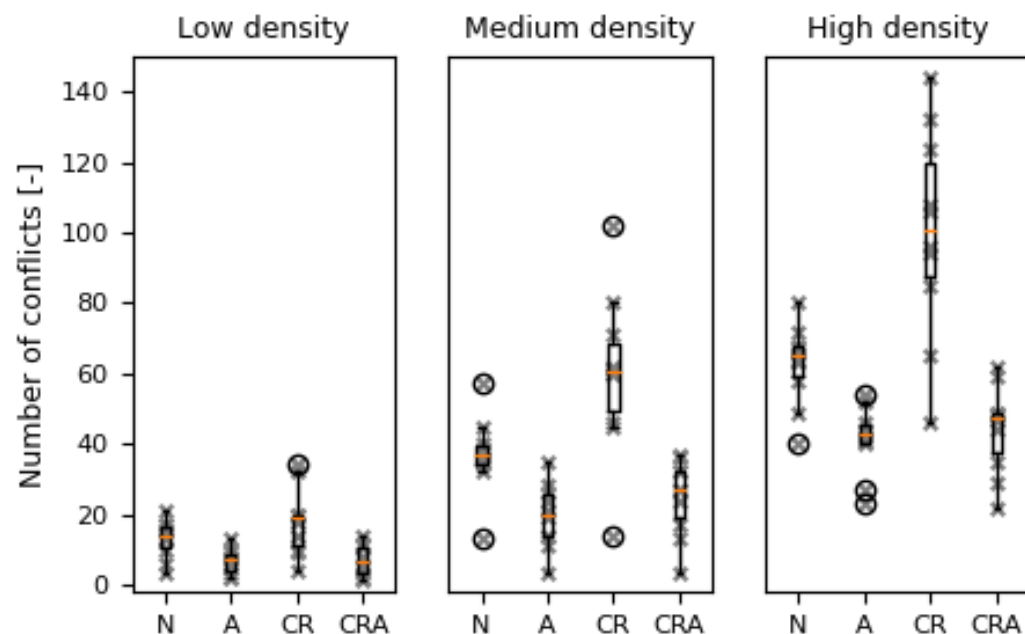
A: Layered Airspace (CR-OFF)

CR: Conflict Resolution (one cruising layer)

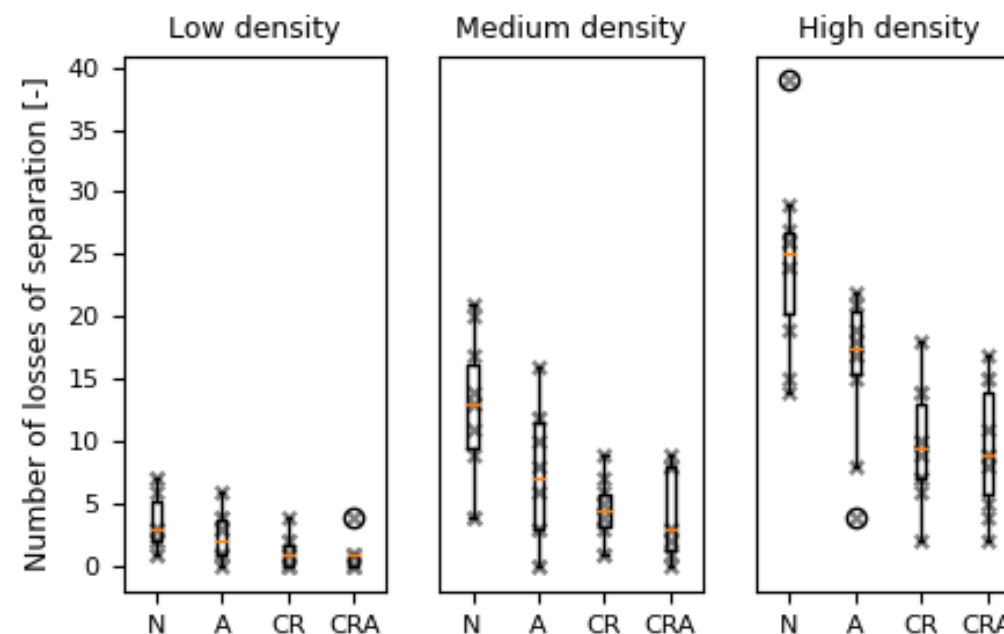
CRA: Conflict Resolution + Layered Airspace

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Total Number Conflicts



Total Number Losses of Separation



Results

Legend:

N: None (CR-OFF + one cruising layer)

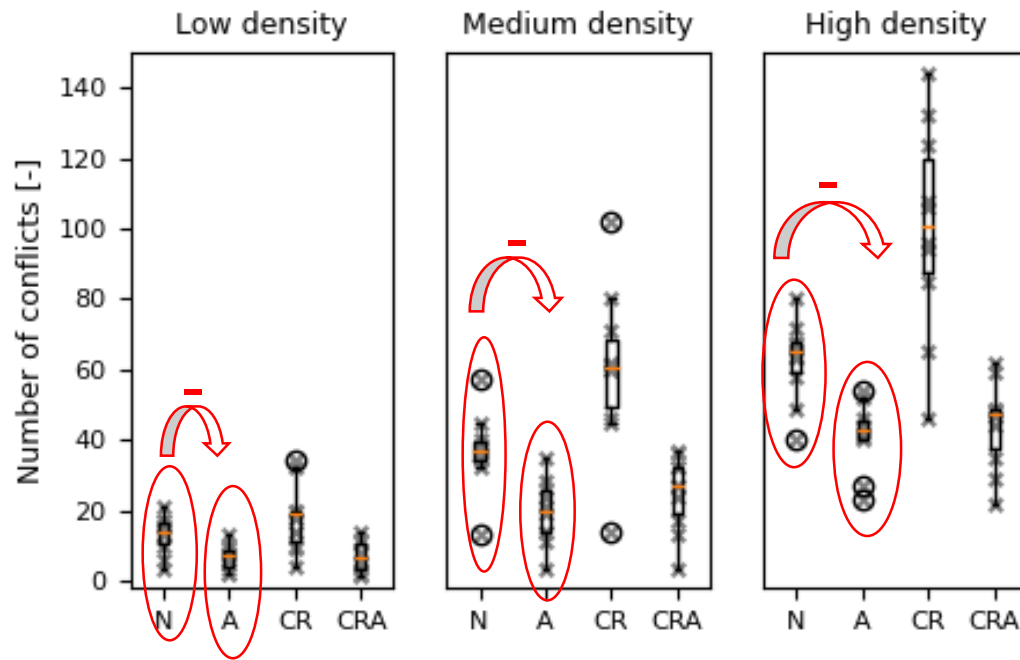
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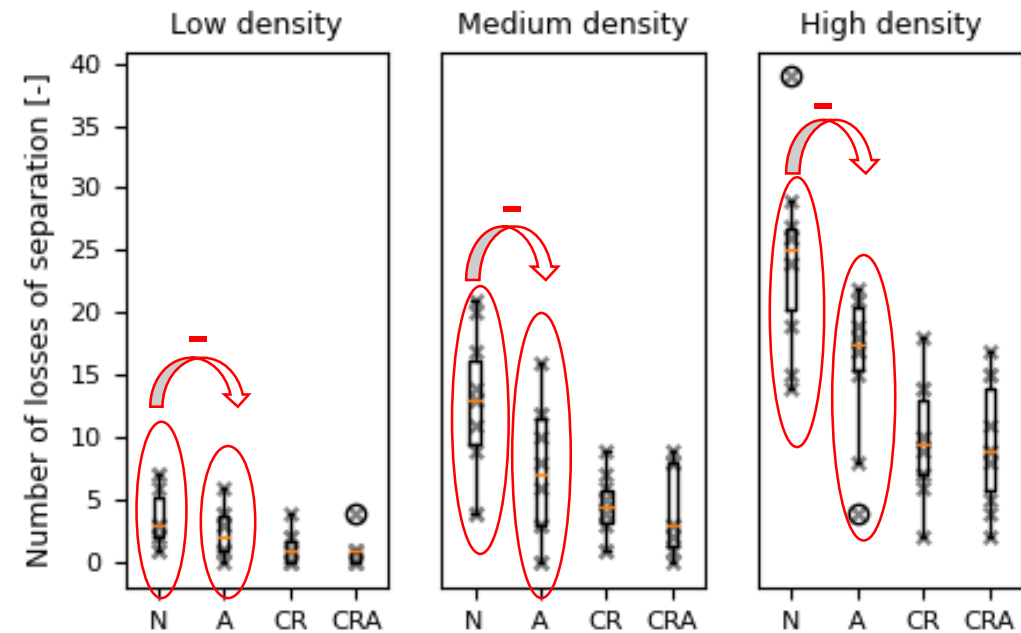
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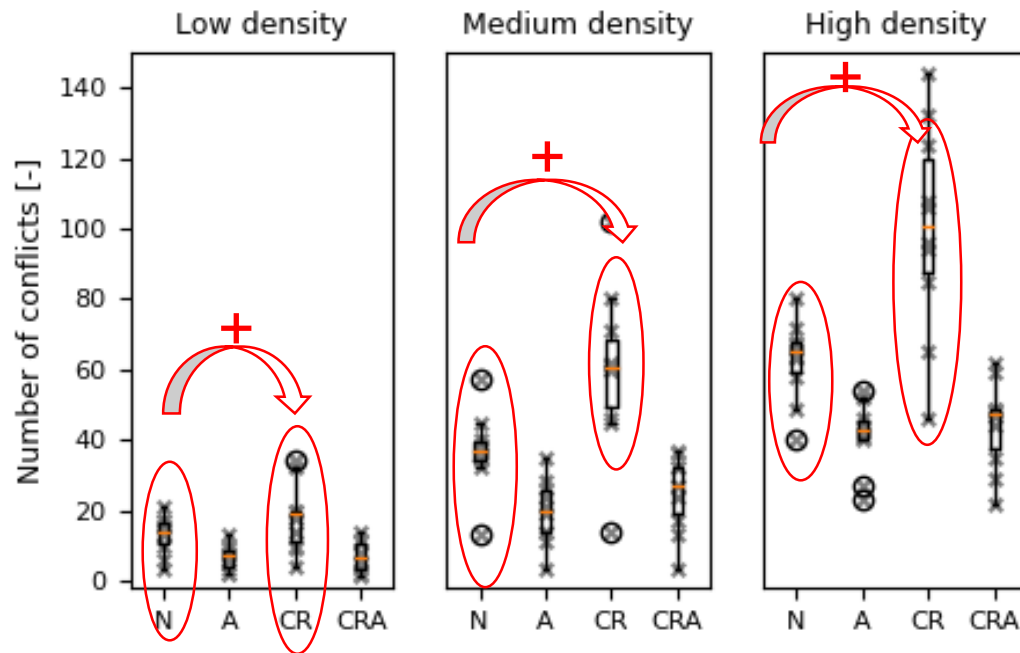
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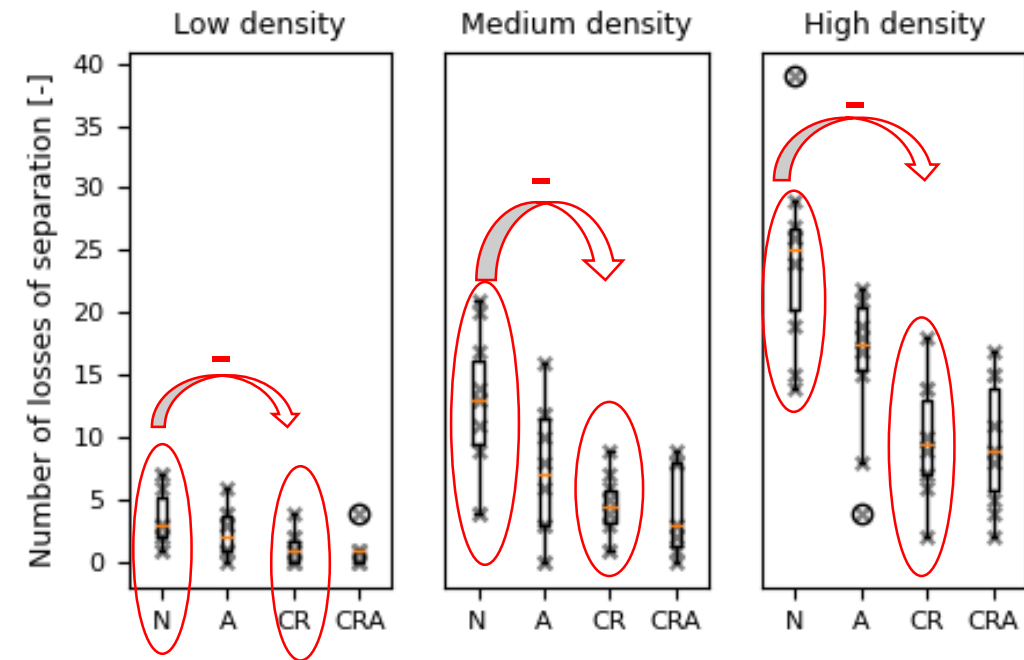
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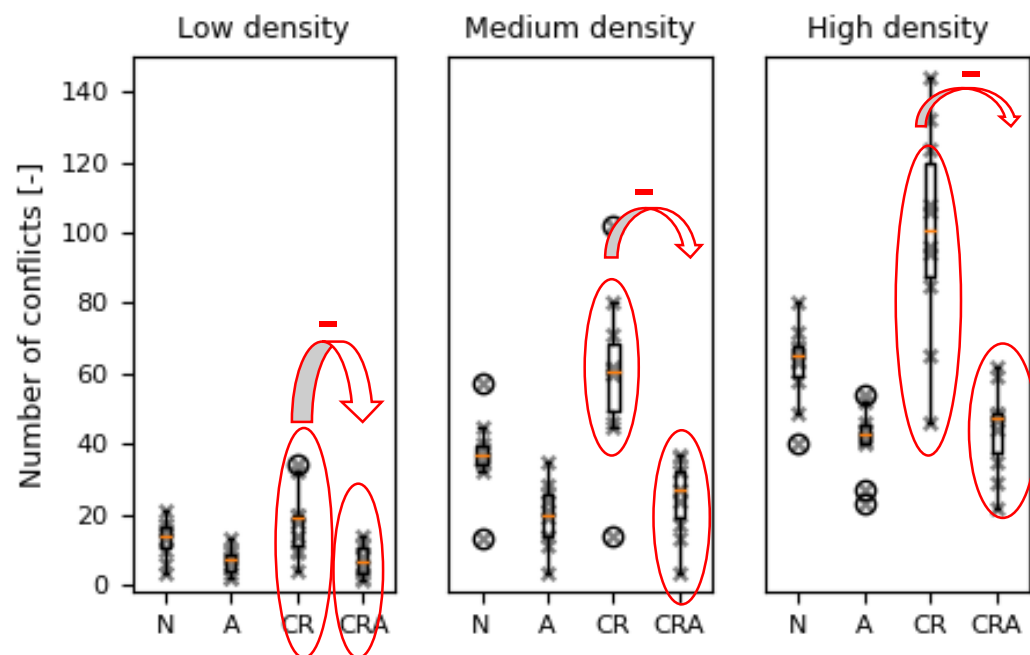
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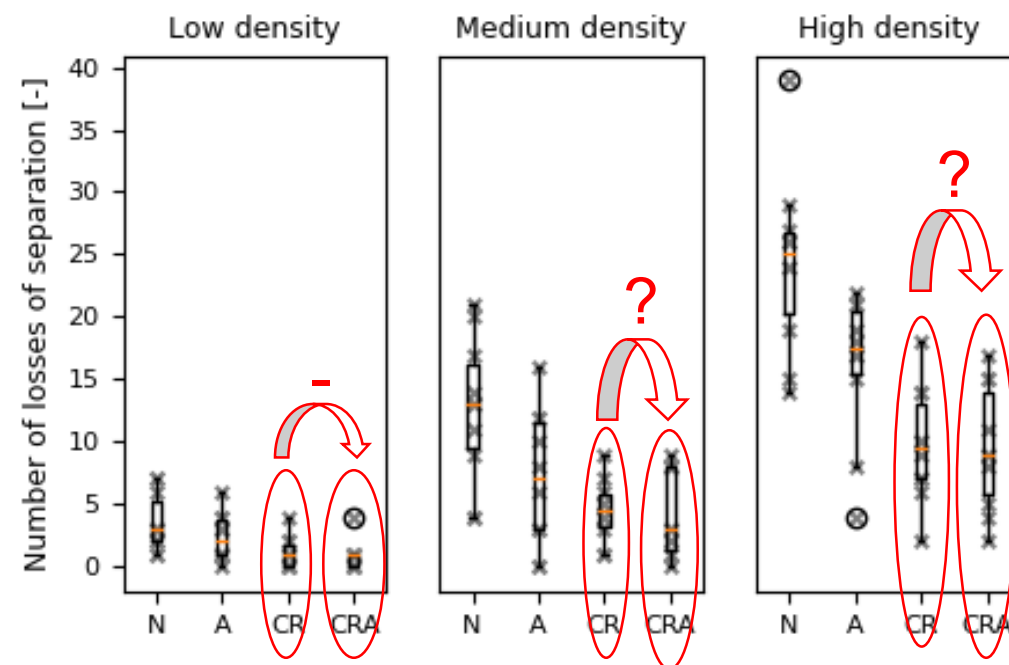
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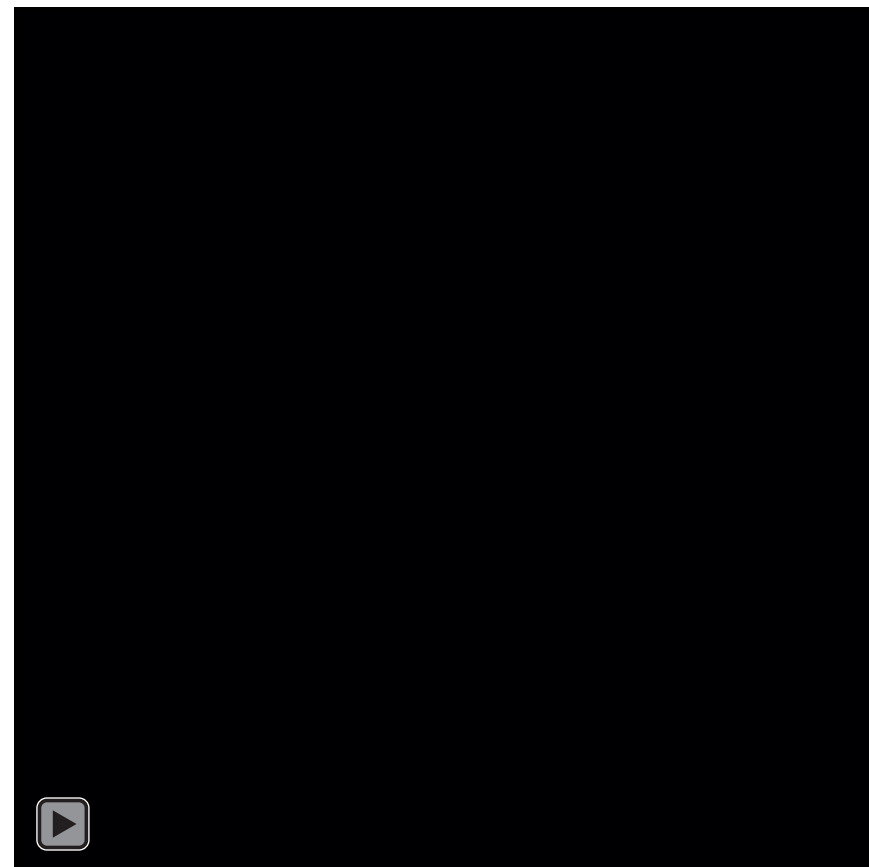
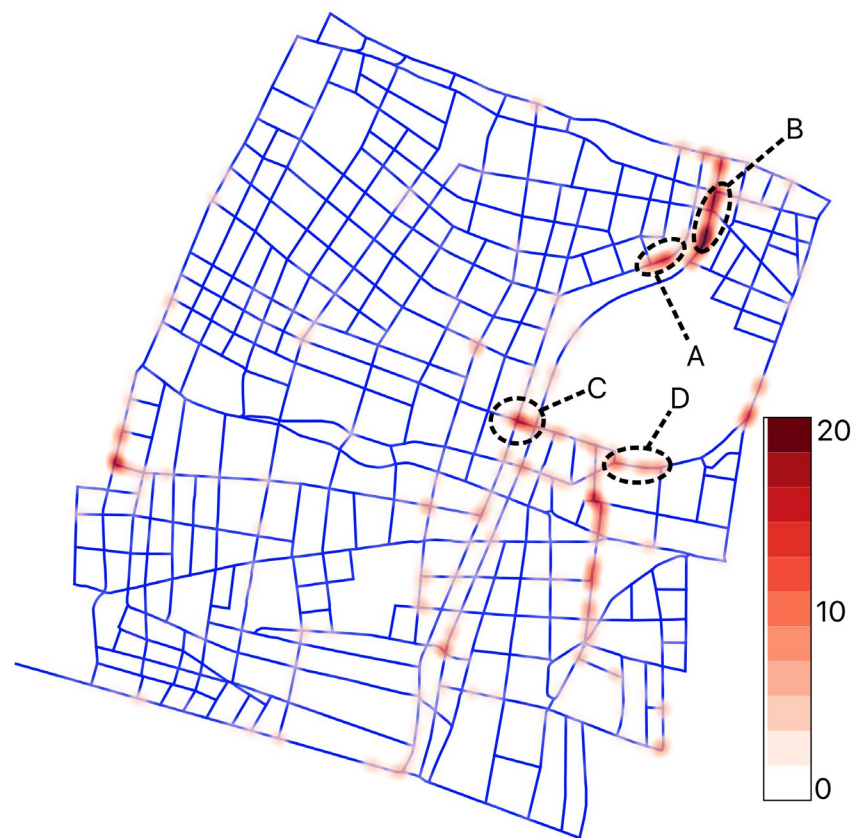


Total Number Losses of Separation



Results

Conflict Pairs Heat-Map

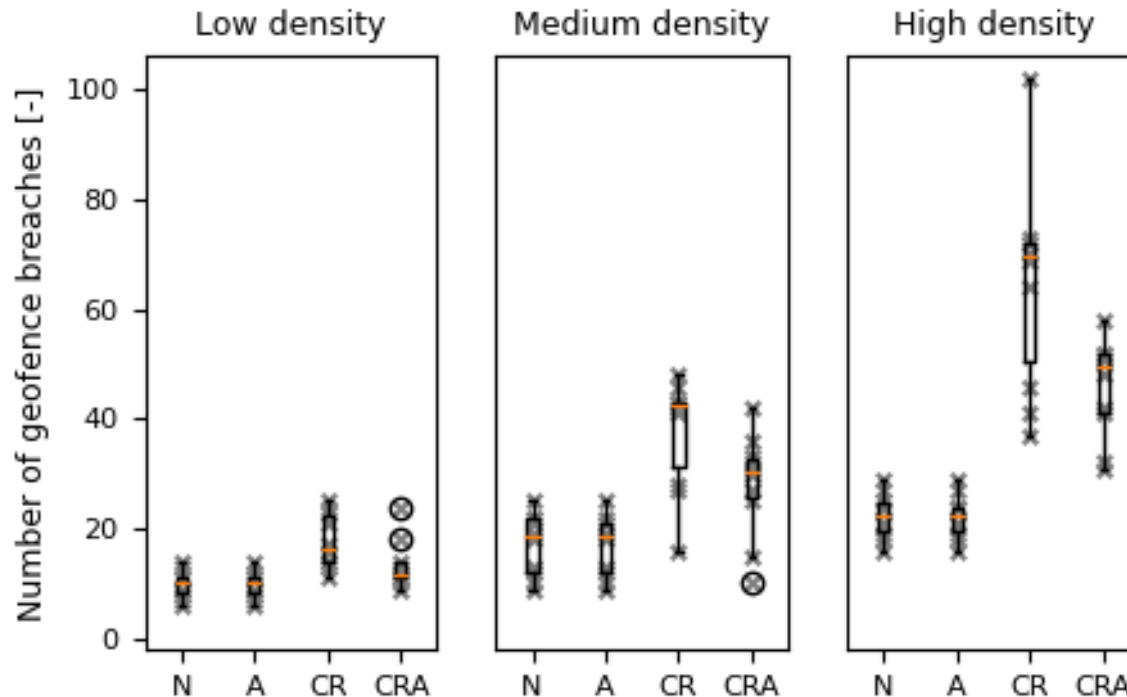


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Building breaches

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Total Number of Building Breaches



Legend:

N: None (CR-OFF + one cruising layer)

A: Layered Airspace (CR-OFF)

CR: Conflict Resolution (one cruising layer)

CRA: Conflict Resolution + Layered Airspace

Conclusion

- Merging in constrained airspace is an unsolved problem and needs further research.
- Deconflicting manoeuvres must consider maximum turn radius.
- Conflict detection should consider street layout.

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Future Work

- Investigating vertical conflict resolution.
- Applying merging/diverging rules.

Thank you!

Questions?



11th SESAR Innovation Days

