

9th SESAR INNOVATION DAYS

9th SESAR Innovation Days



Young Scientist Award winners presentations
David Bowen, Chief ATM, SESAR Joint Undertaking

2 – 6 December 2019, Athens, Greece



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Three shortlisted candidates...

Leonid Sedov

Javier Alberto Perez Castan

Junzi Sun



Unmanned Traffic Management



9th SESAR Innovation Days

Leonid Sedov



<https://undefined.github.io/>

2 – 6 December 2019, Athens, Greece



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Unmanned Traffic Management



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Unmanned Traffic Management



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Hop topic

- Worldwide

Axiom: UAV operations 

Empirical proof: Look around

Theorem: UTM research 

Proof: Academia trims sails to the wind

- Main theme of conferences (DASC'16, I-CNS'17, et al), UTM tracks
- Amazon, Google, NASA



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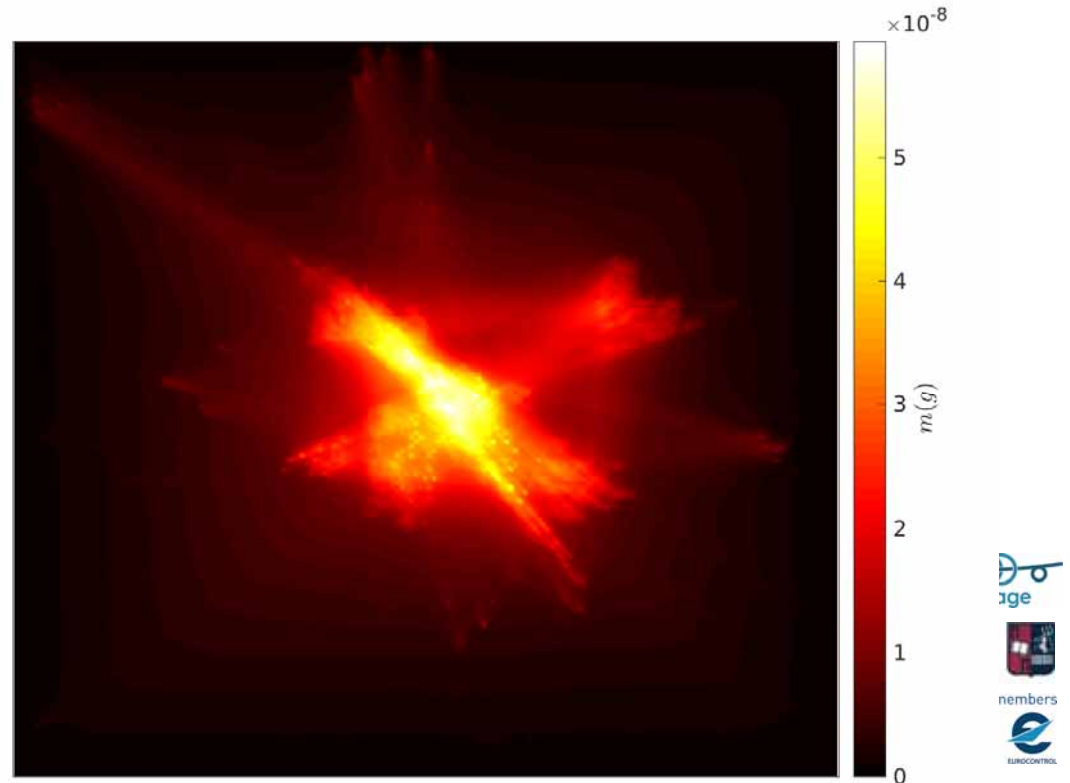
Uniform distribution?

Population density

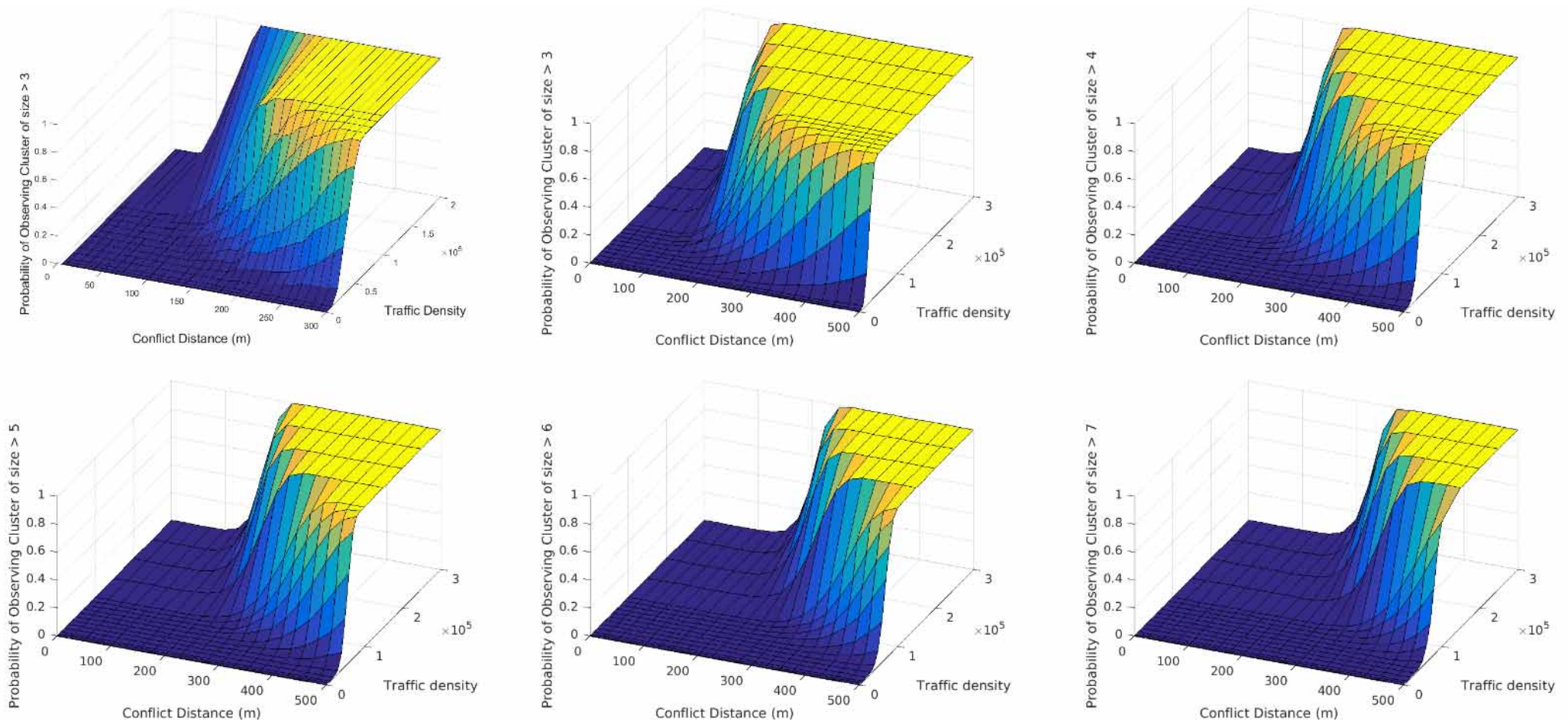


Expected traffic density

How likely it is to see a drone?



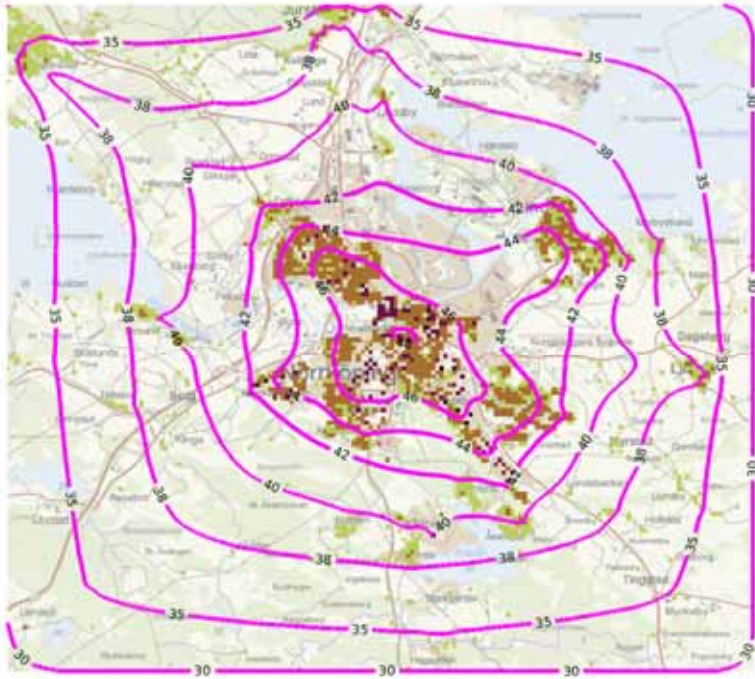
Conflict rates



Noise footprint

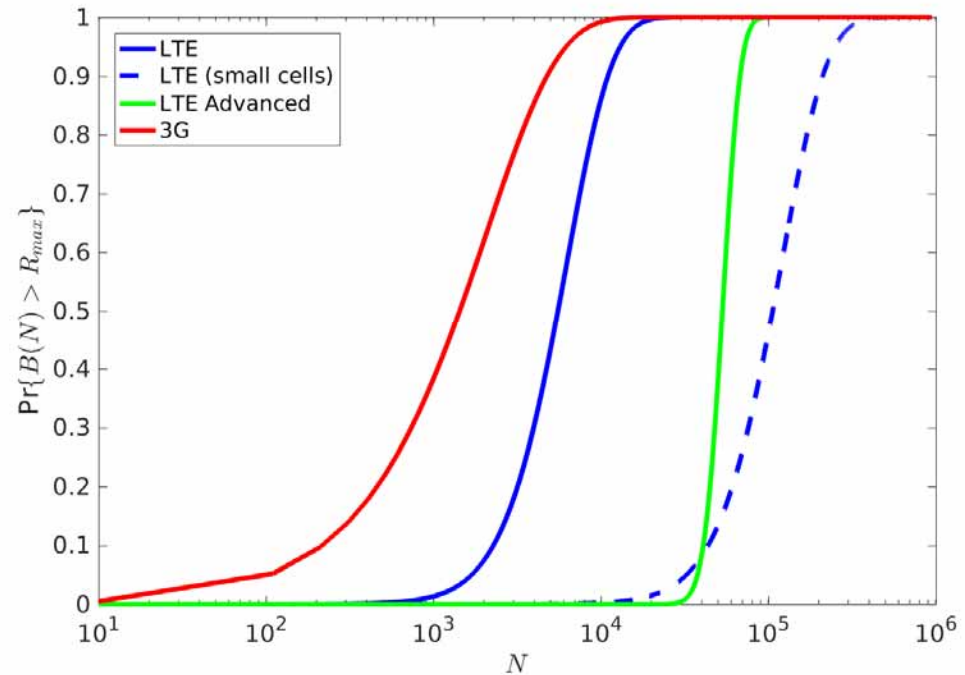
5000 flights, $h = 50\text{m}$

Noise = 60dB under drone

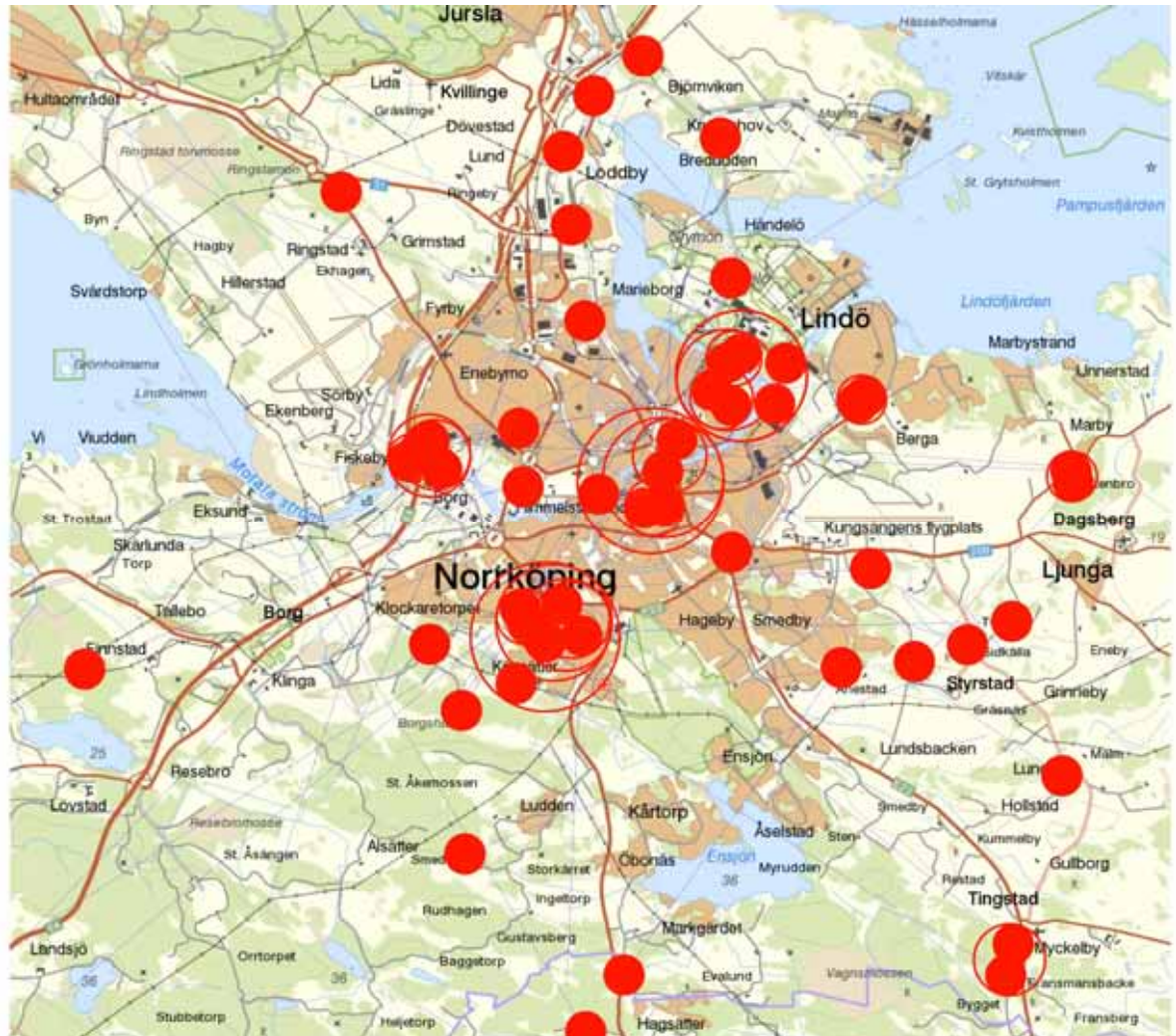


Data rate capacity

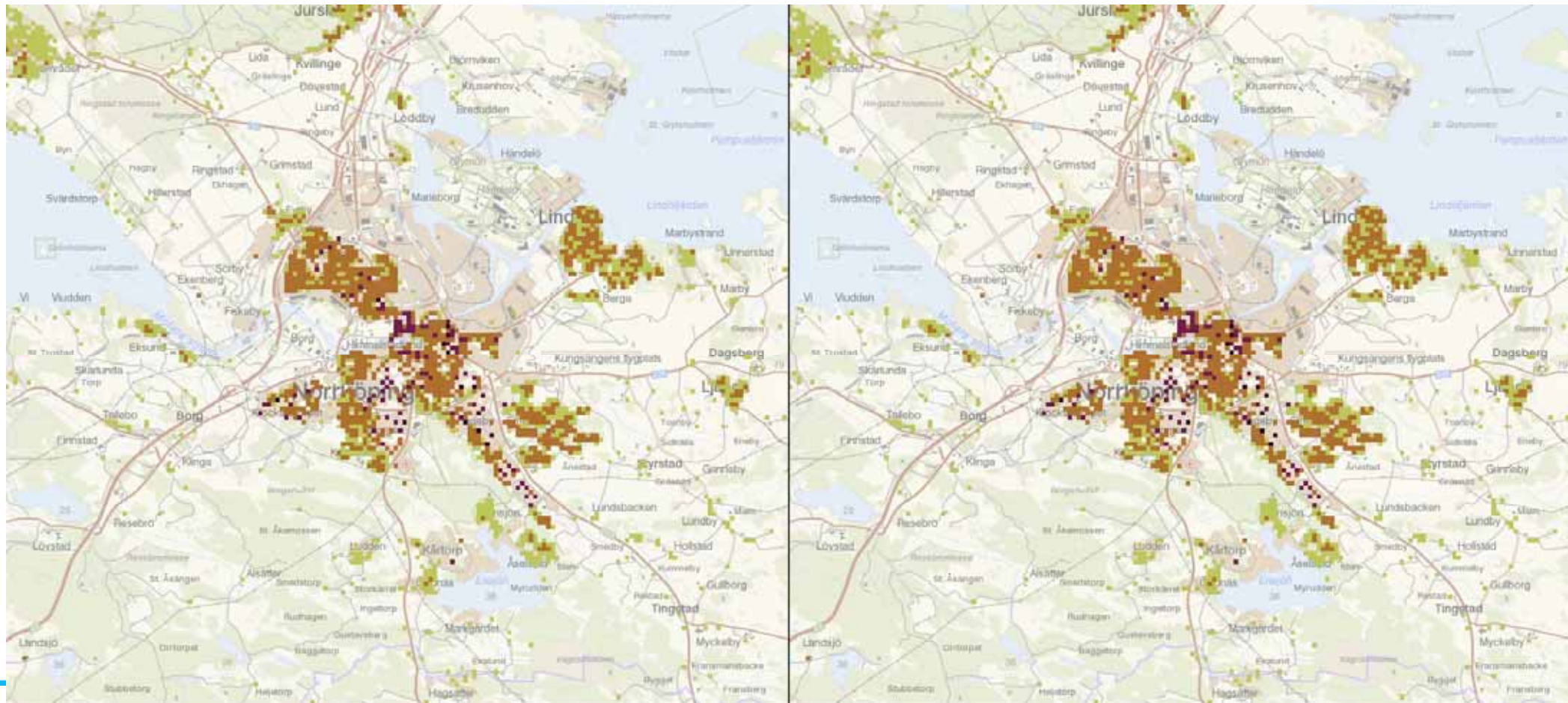
5 Mbps/drone (720p video)



Decentralized GDP



Decentralized GDP, static vs dynamic geofences





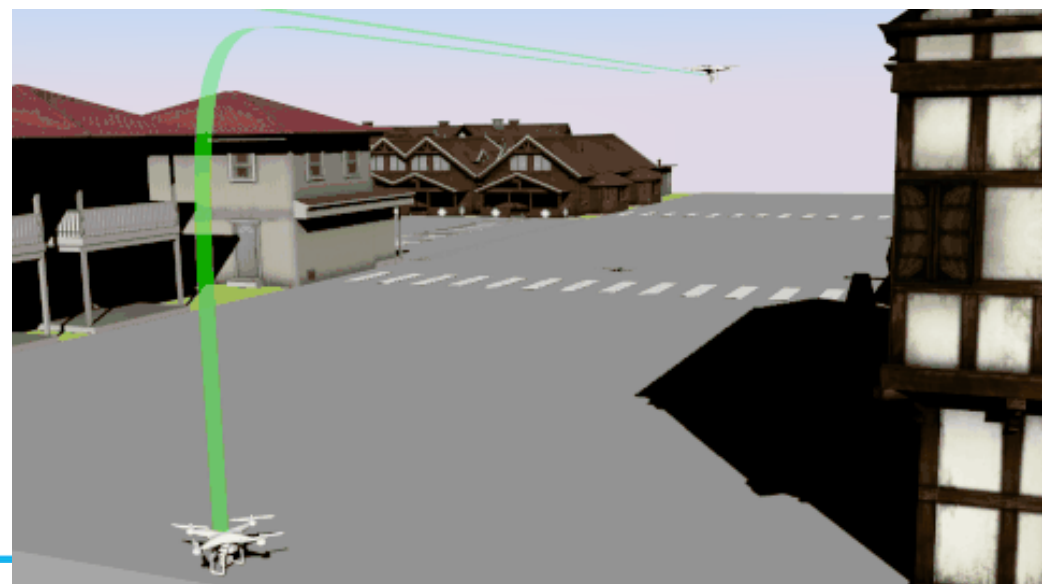
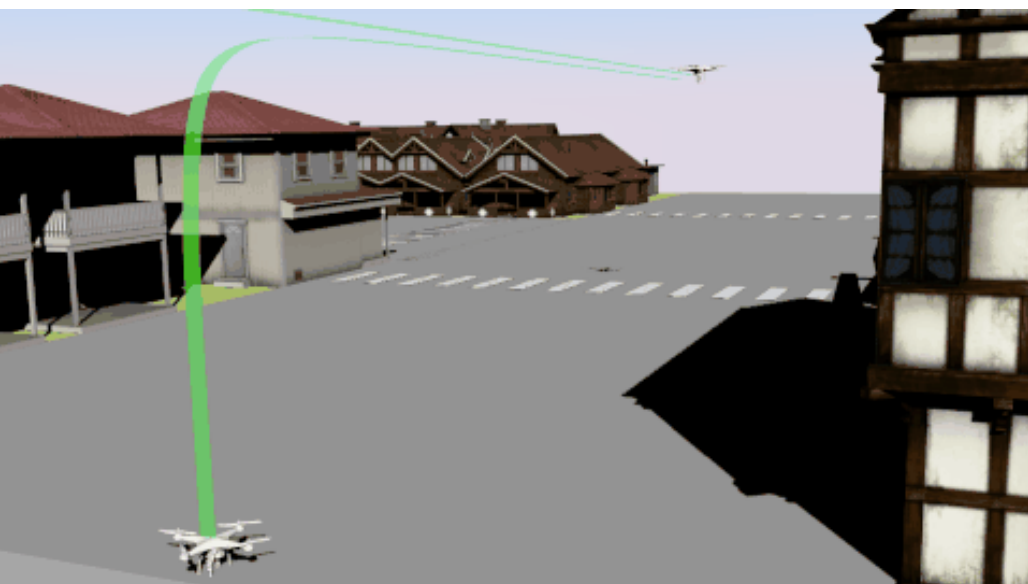
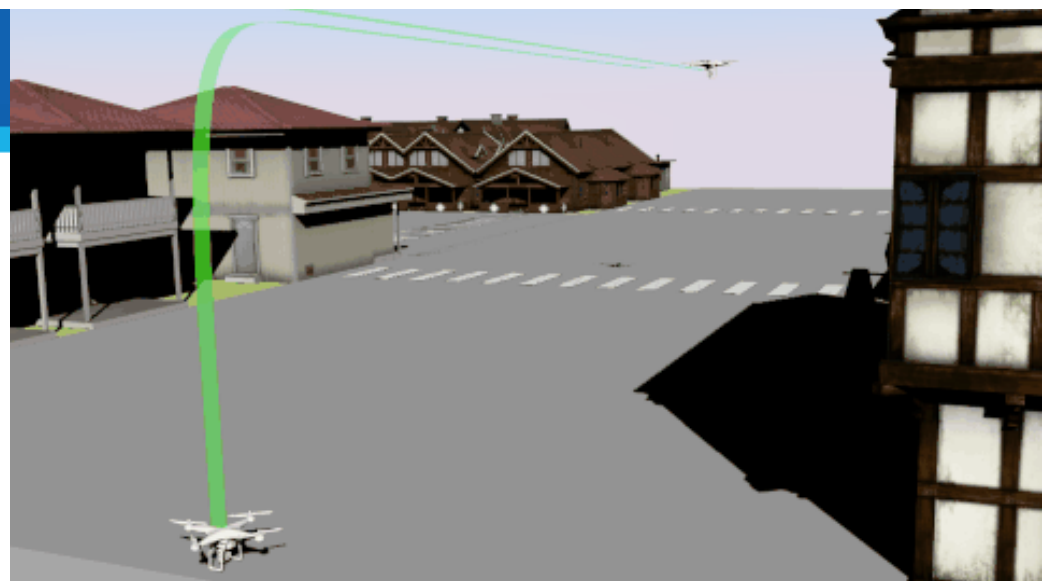
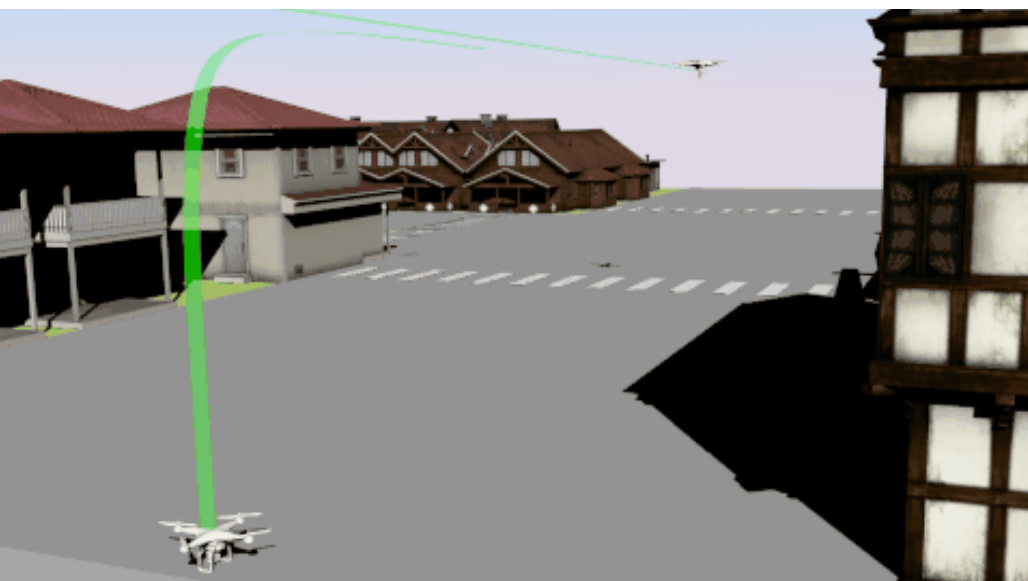
Conflict resolution algorithms

	Single-layer	Multi-layer
Centralized	Ground delay	Layer assignment
Distributed	Hovering	On-demand descending



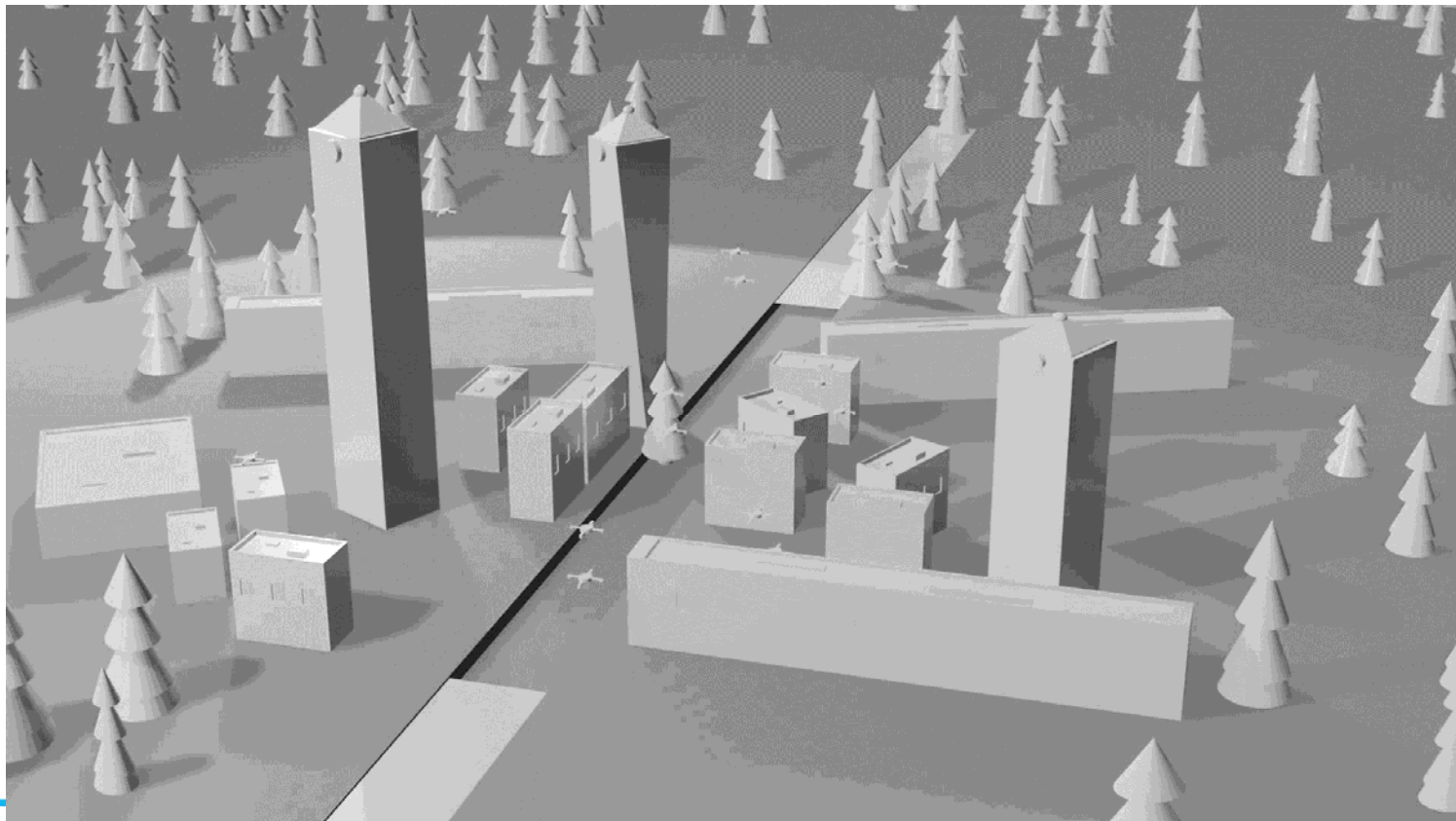
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ICRAT'18 => 12 layers over a city (too many)

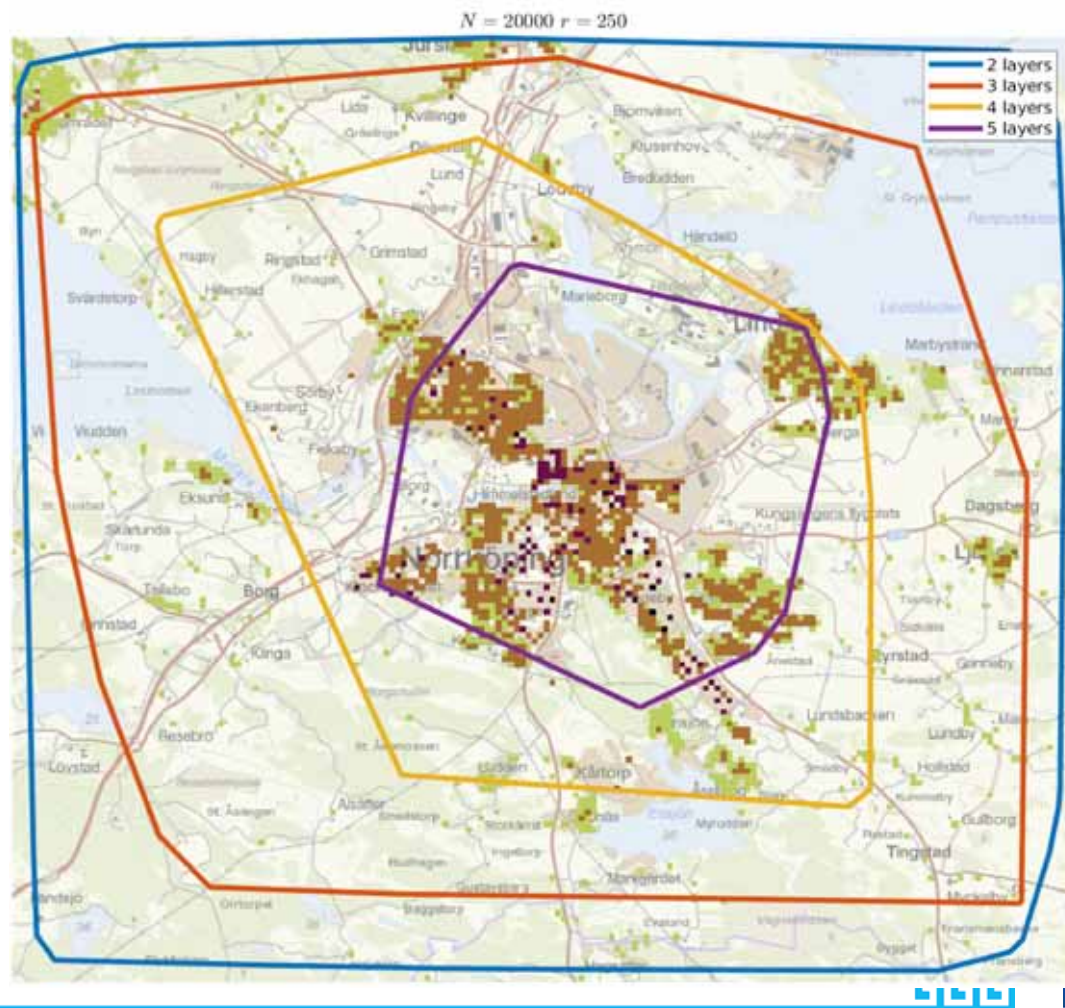
Why the same layers everywhere?



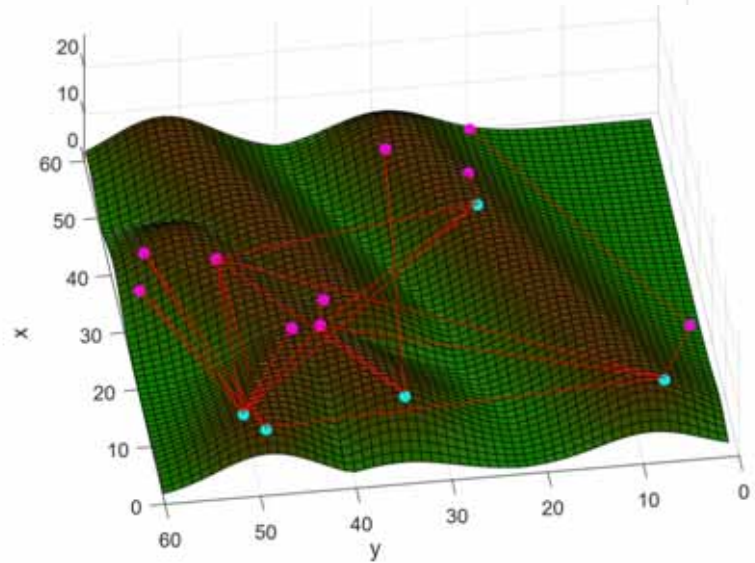
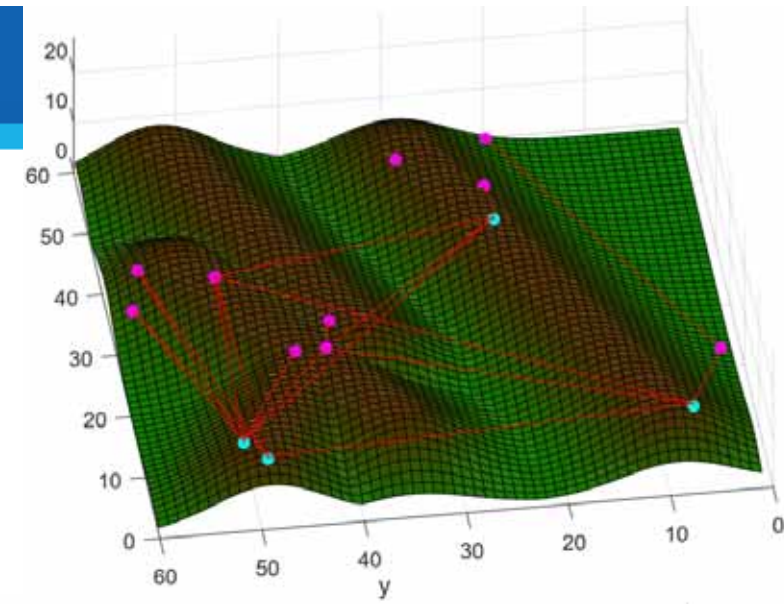
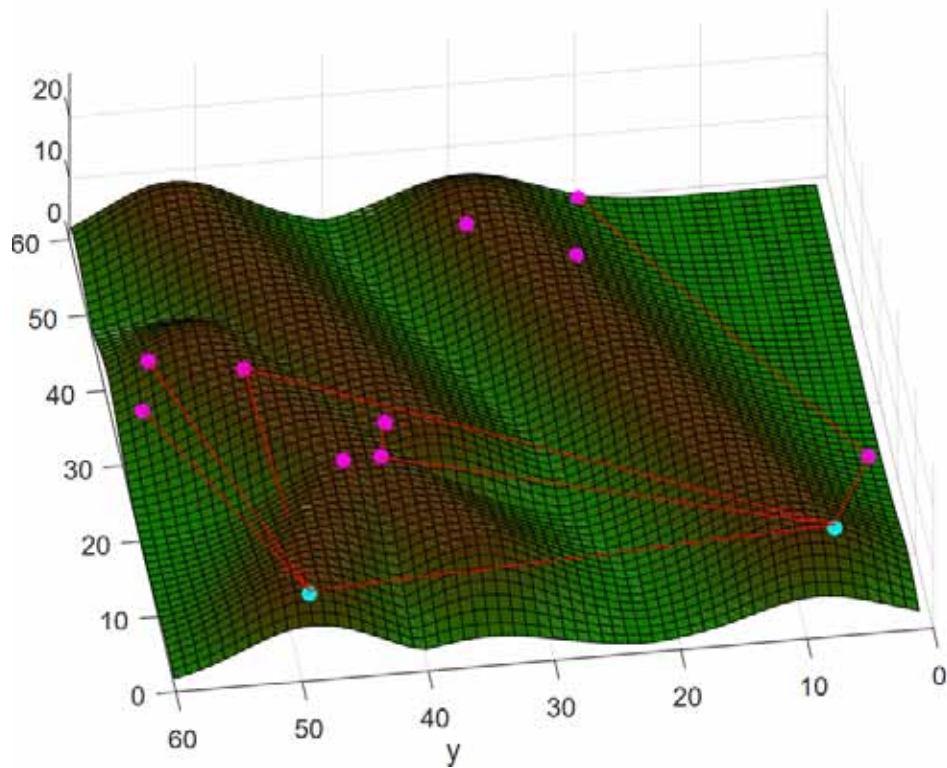
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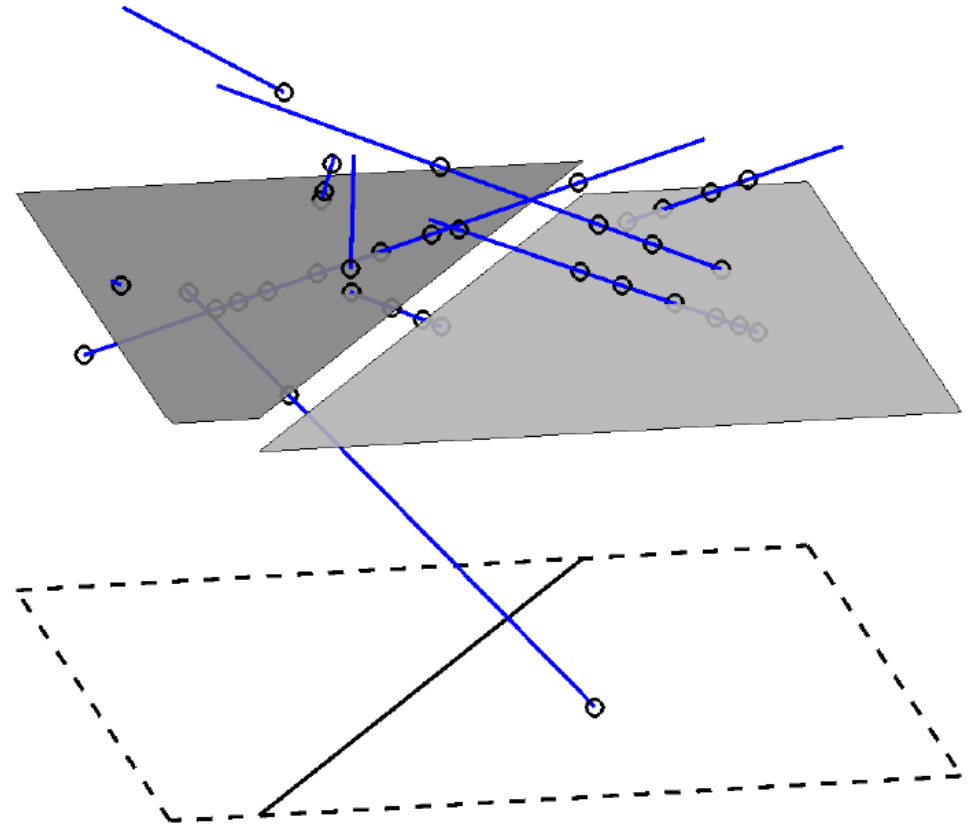
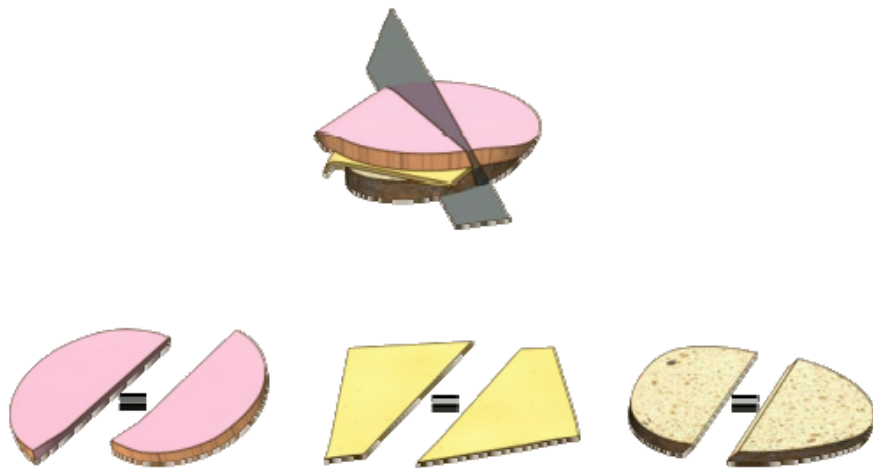
Adaptive # of layers = PBN for UTM



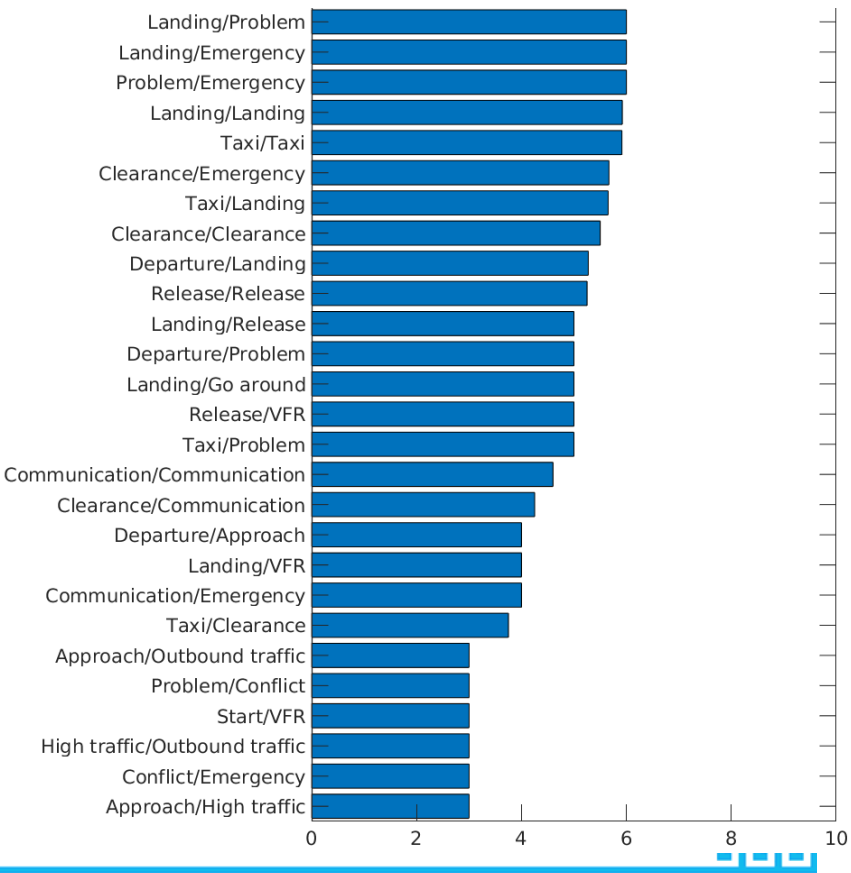
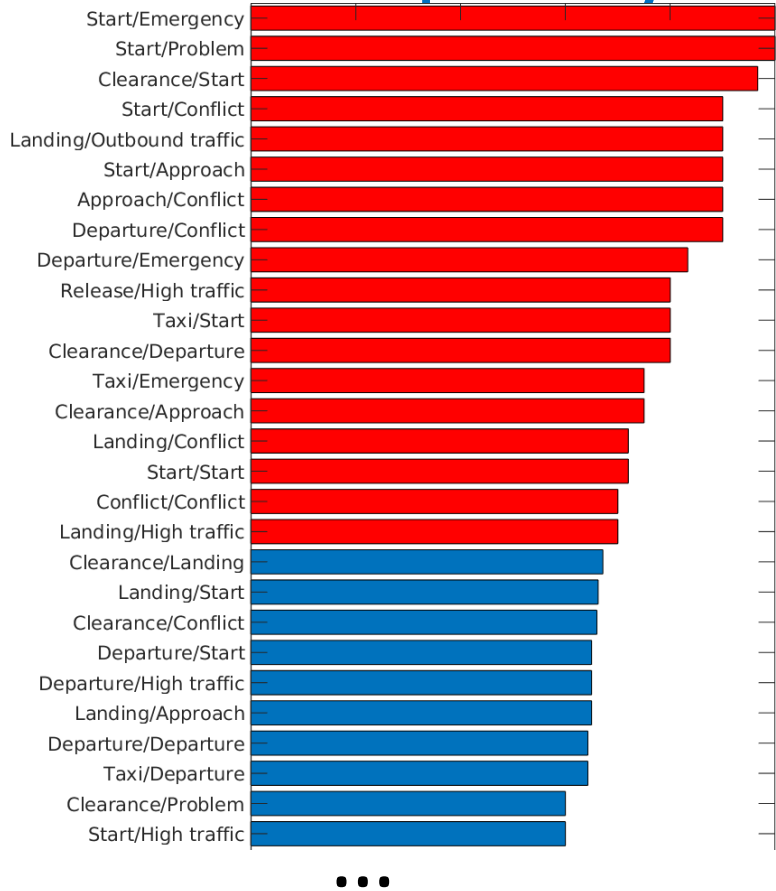
Also BBTM for UTM



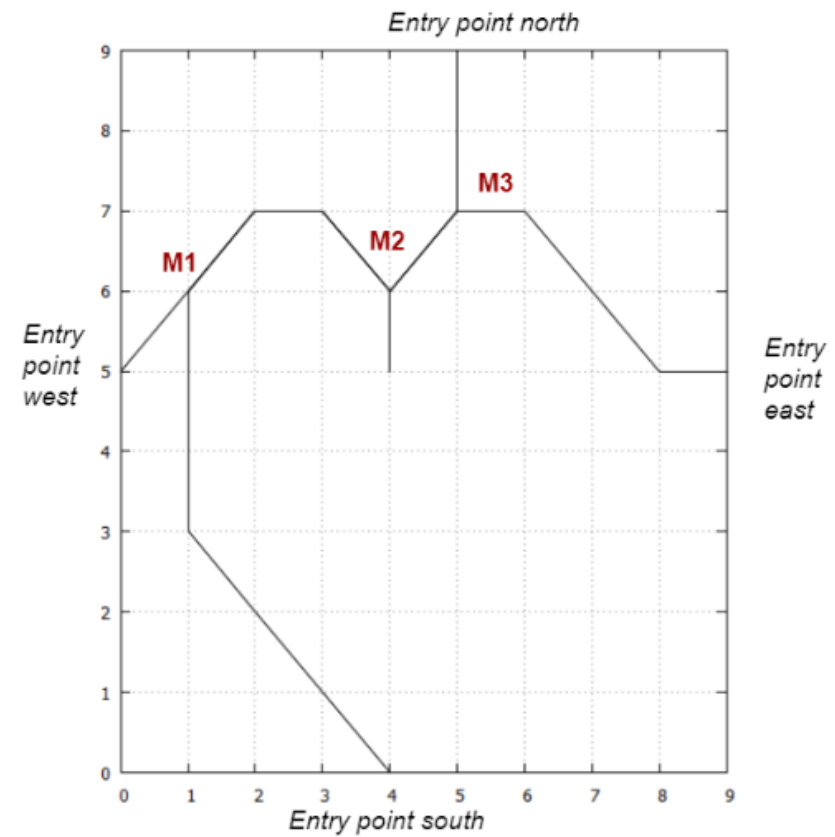
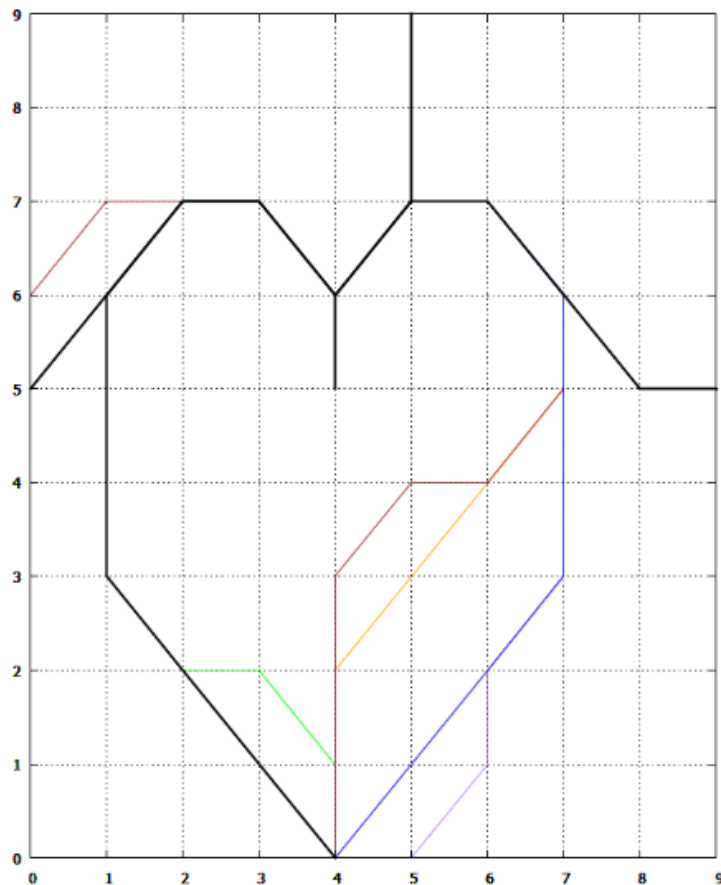
And ATM sectorization



And complexity



And design of arrival routes



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I was not alone





Impact of Continuous Climb Operations in a high traffic density TMA

PhD Javier Alberto Pérez Castán

Thesis supervisor: PhD V. Fernando Gómez Comendador



POLITÉCNICA

Universidad Politécnica de Madrid

December, 5 2019
Athens

2 – 6 December 2019, Athens, Greece



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INTRODUCTION

- Justification
- Motivation

1



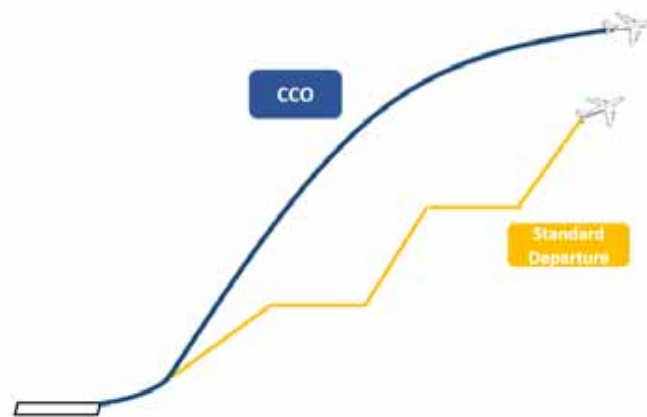
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CCO operational concept

ICAO defines a CCO as “an aircraft operating technique enabled by **airspace design**, **procedure design** and **facilitation by ATC**, allowing for the execution of a flight profile optimised to the performance of the aircraft...”.

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Operational goal

CCO is free of ATC actions from the departure to the cruise level

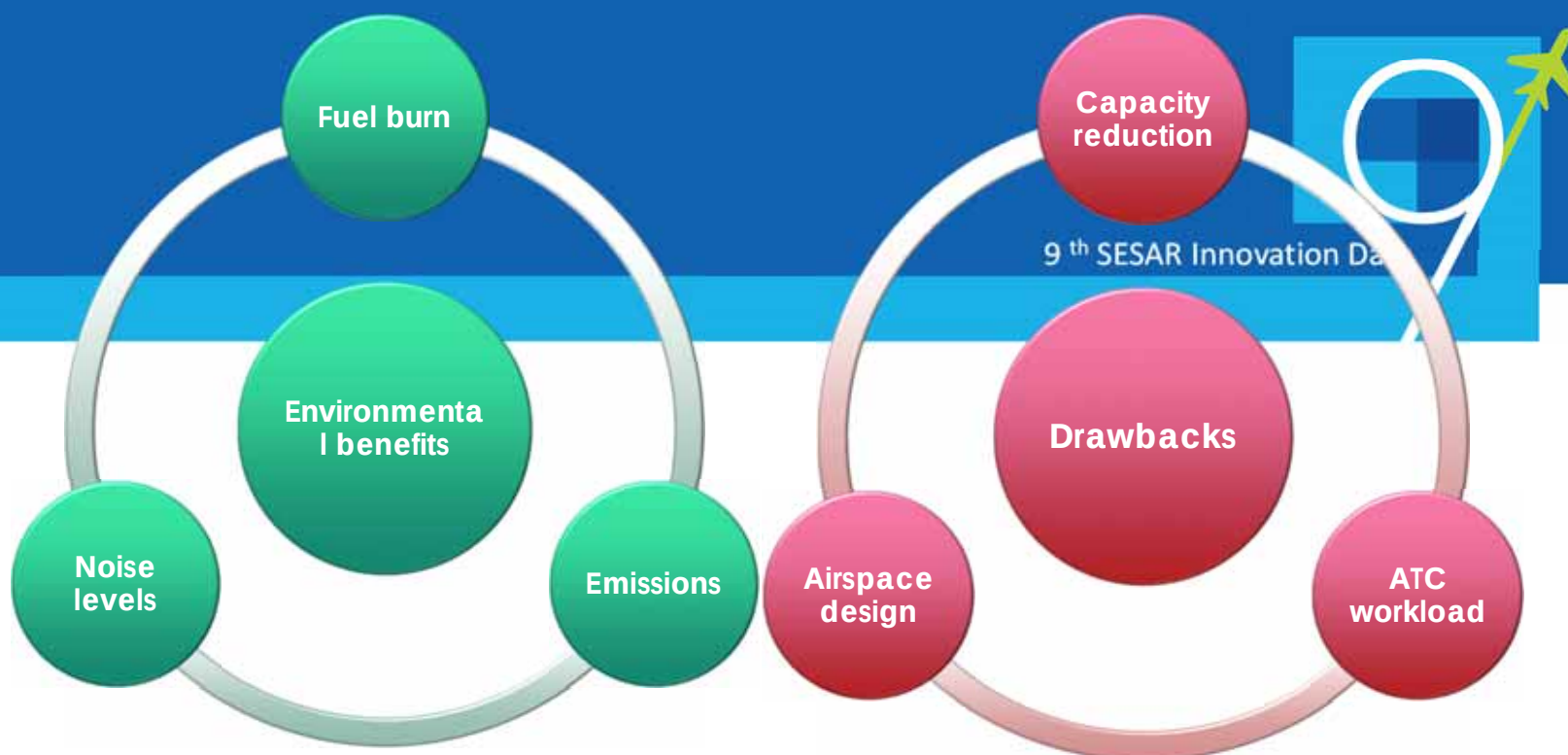
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Expected results



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Motivation

Motivation

Is it feasible to integrate CCOs in a high-density scenario?

What is their impact on safety and capacity?

Is current airspace design acceptable?

Which modifications and improvements are required?



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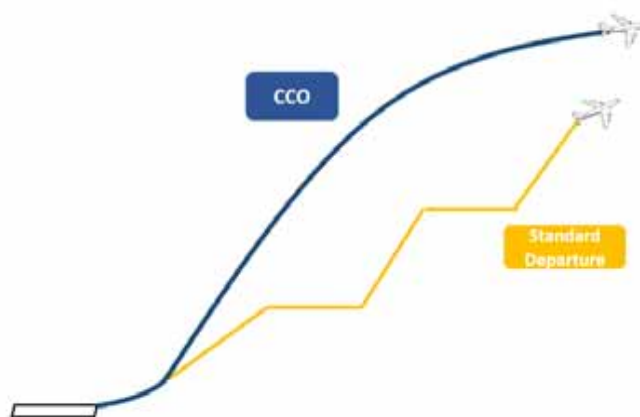
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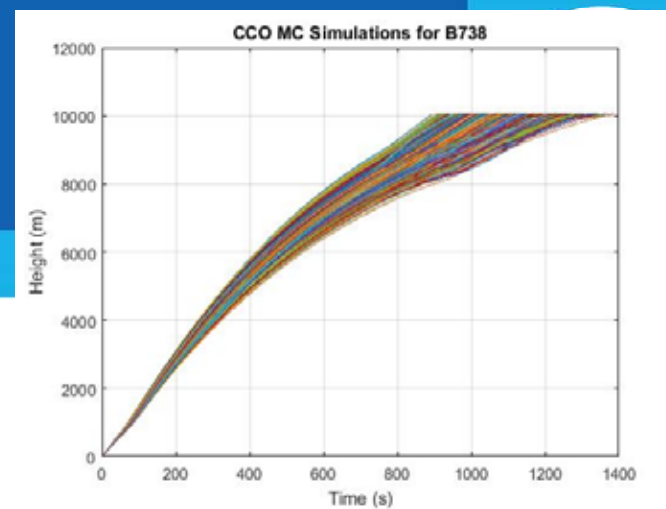
CCO modelling to obtain fuel-burn optimised trajectories

2



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Quantification of new separation minima

3

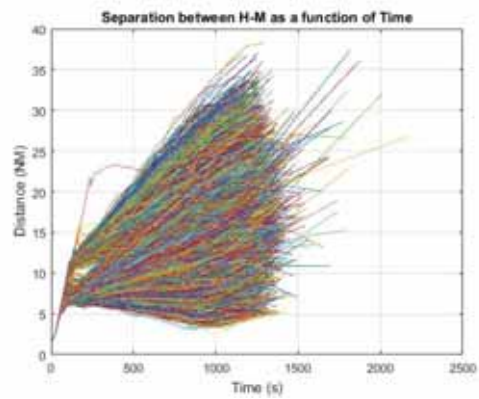


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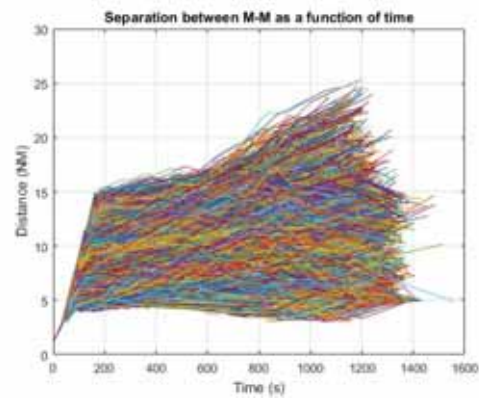




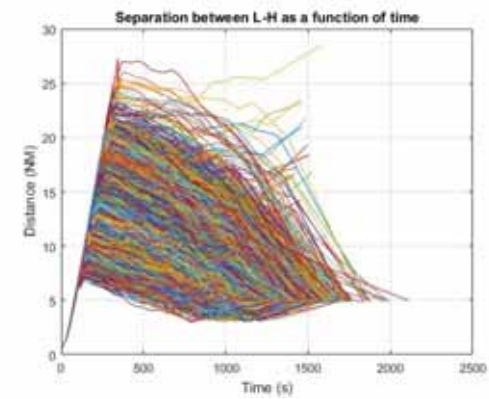
H-M



M-M



L-H

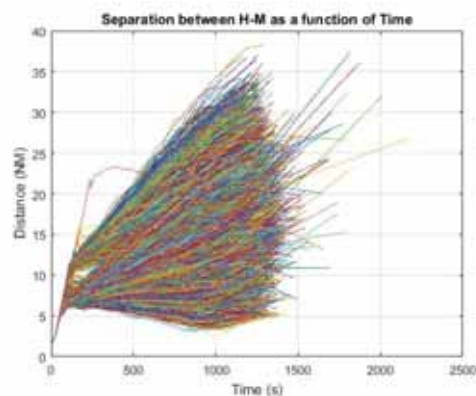


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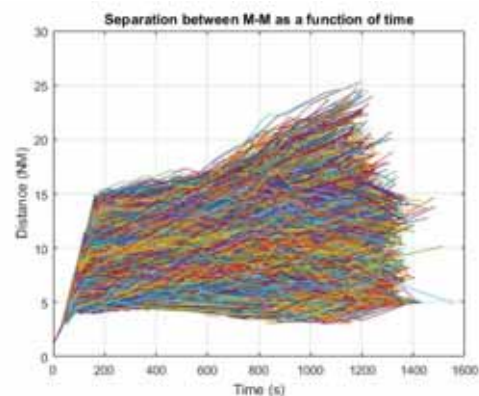




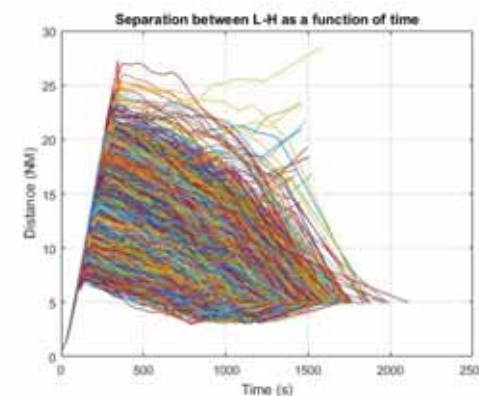
H-M



M-M



L-H



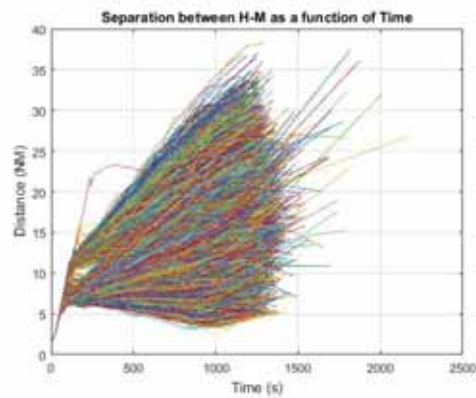
CCO		Initial separation minima			Proposed separation minima		
Leading	Trailing	Light	Medium	Heavy	Light	Medium	Heavy
Light		61	61	61	153	202	368
Medium		71	60	60	85	110	207
Heavy		86	77	68	90	80	113



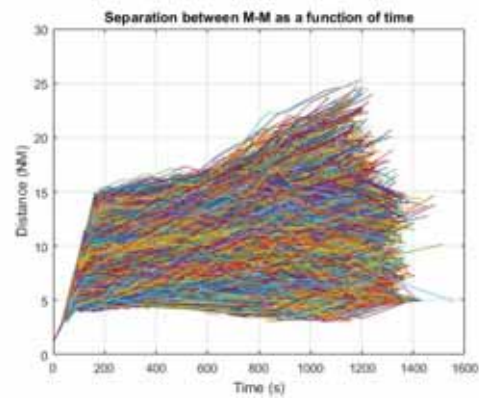
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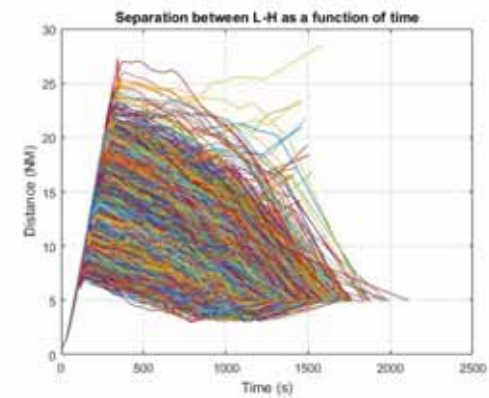
H-M



M-M



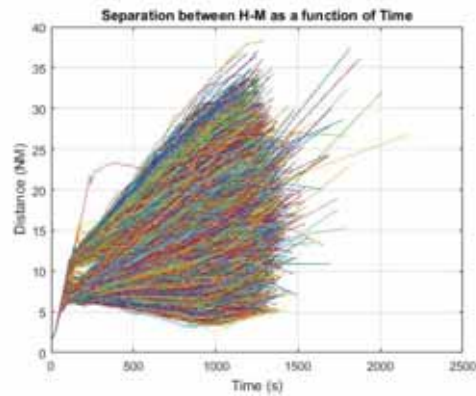
L-H



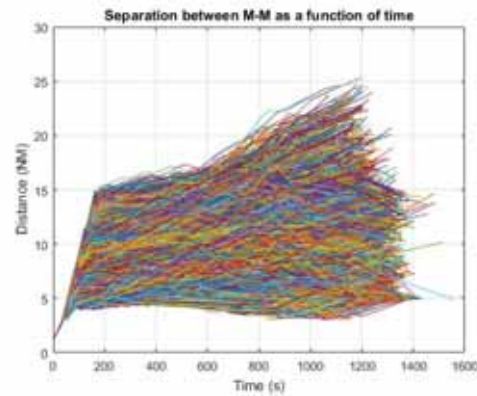
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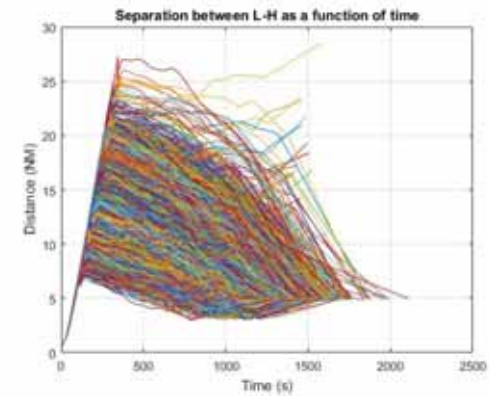
H-M



M-M



L-H



CCO		Initial separation minima			Proposed separation minima		
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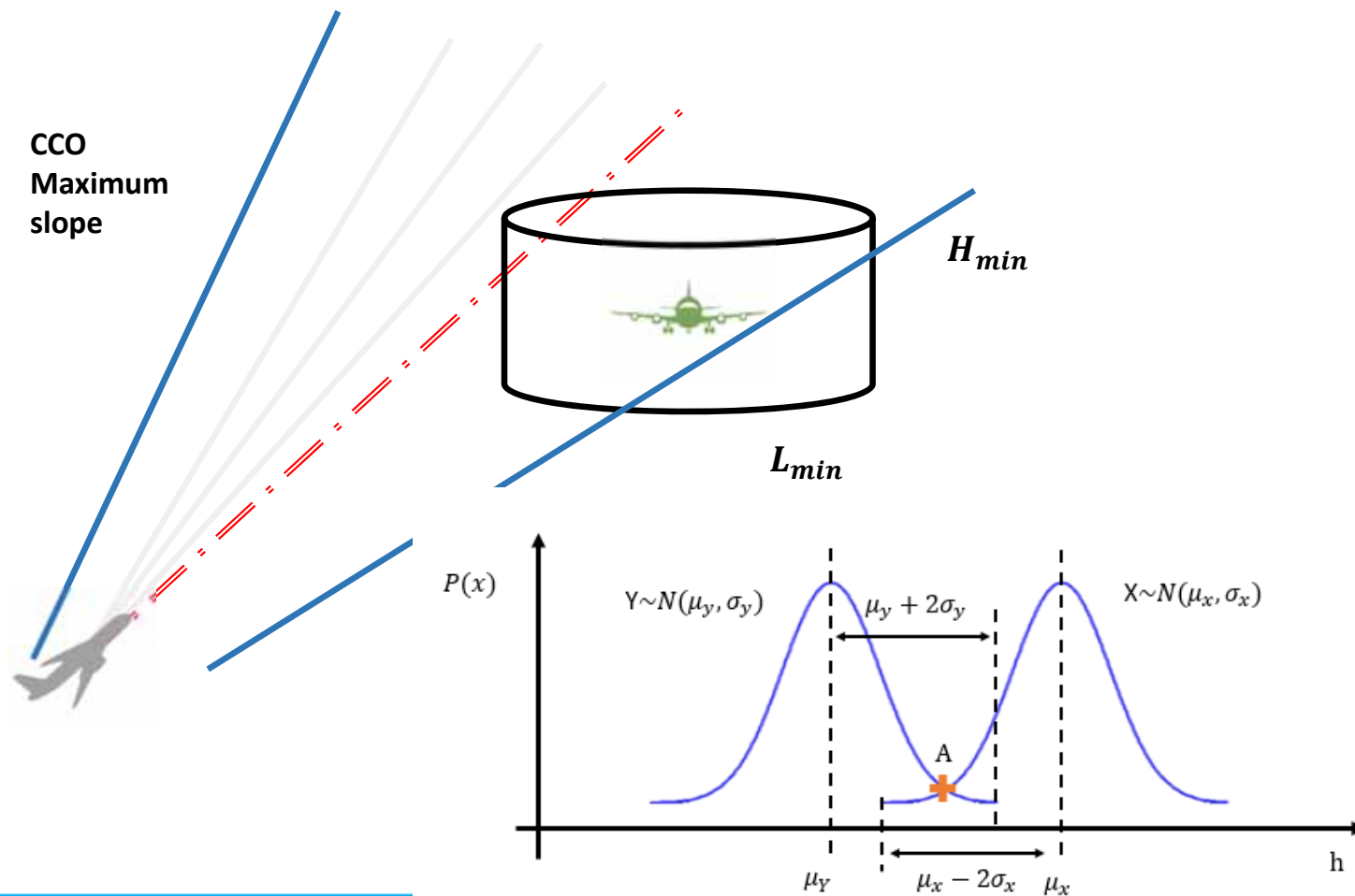
Development of a conflict-risk methodology to assess airspace design

4

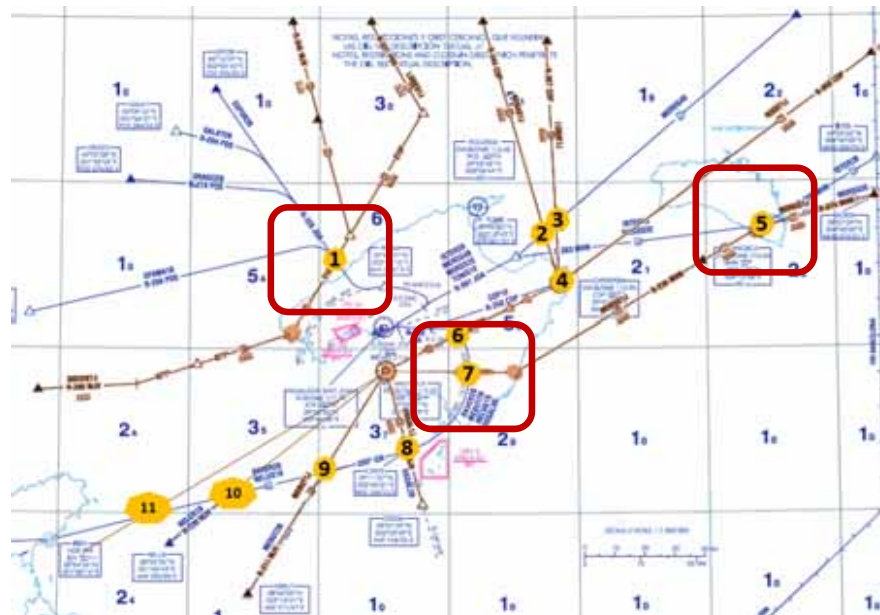


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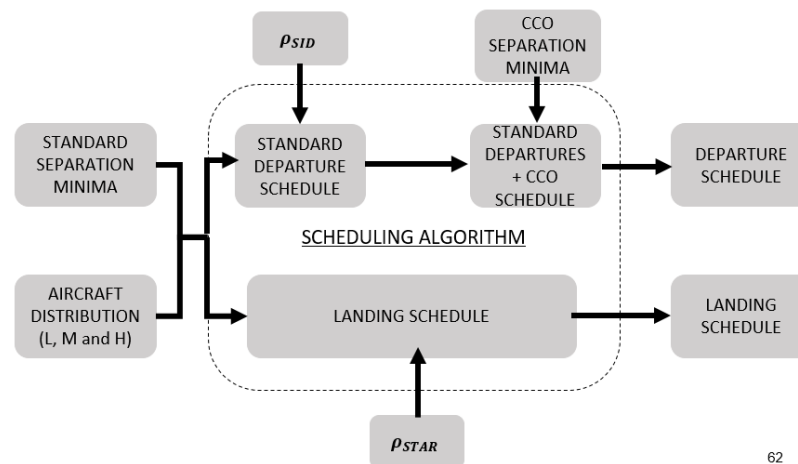


Conflict point r	P_r^p	P_r^q	P_r^c	CR_r
1	0.418	0.3523	3.3E-3	4.9E-4
5	0.032	0.0134	4.5E-3	1.9E-6
7	0.086	0.0134	3.9E-4	4.5E-7



CCO impact on capacity

5



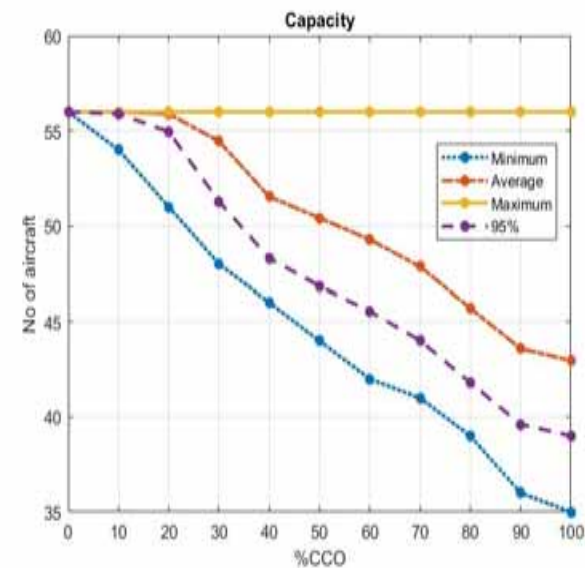
10 experiments

CCO Rate varies
from 0% to 100%.

Each experiment is repeated 10^4

Variables:

- Arrival and departure schedules,
- Routing distribution,
- CCOs and arrivals trajectories.



- CCO rate $\uparrow$ $\rightarrow$ Capacity $\downarrow$
- Optimisation scheduling process $\rightarrow$ Capacity $\uparrow$



CONCLUSIONS & FUTURE WORKS

6

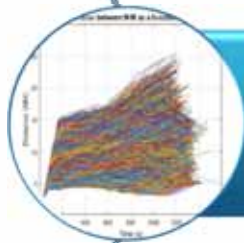


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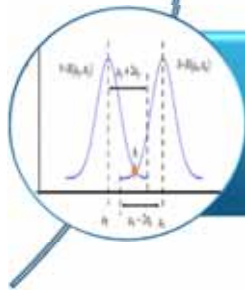




This dissertation provides a **methodology** to evaluate the integration of CCOs considering safety and capacity



New **CCO separation minima** are larger than standard separation minima



A new **conflict-risk model** is laid out to assess the conflict probability between CCOs and arrivals based on altitude distributions



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Conflict-risk model allows to assess whether **current airspace design** is valid or not



Capacity assessment is carried out by the development of a scheduling algorithm, a CD&R algorithm, and MC simulations to statistically analyse the CCO impact on the theoretical capacity.



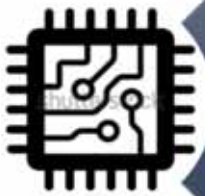
CCO integration is **feasible in Palma** although it requires airspace-design modifications and optimisation scheduling process



Further work



Improvements in path predictability and uncertainty modelling as well as to consider more aircraft models and optimised trajectories



To design an **ATC-tool** to dynamically calculate an ad-hoc runway separation minima for each CCO pair



These results must be corroborated under real **operational conditions**



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Publications

- 1. Impact of Continuous Climb Operations on Airport Capacity.** *Transportation Research Part C: Emerging Technologies*, 2019, 96, pp. 231-250. DOI: 10.1016/j.trc.2018.09.008.
- 2. Separation minima for Continuous Climb Operations.** *Journal of Aircraft*. Journal of Aircraft, 2019, 56, pp. 262-272. DOI: 10.2514/1.C034667.
- 3. Conflict-risk assessment model for Continuous Climb Operations.** *Aerospace Science and Technology*, 2019, 84, pp. 812-820. DOI: 10.1016/j.ast.2018.11.030
- 4. Design of a conflict-detection ATC-tool for the implementation of Continuous Climb Operations: a case study at Palma TMA.** *Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering*. Online published. DOI: 10.1177/0954410019821109



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Thank you for your attention.
Any questions?



9th SESAR Joint Undertaking

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School of Aeronautic and Space Engineering
Universidad Politécnica de Madrid



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Open Aircraft Performance Modeling: Based on an Analysis of Aircraft Surveillance Data

9th SESAR Innovation Days



Junzi Sun, Ph.D., M.Sc.

Faculty of Aerospace Engineering
Delft University of Technology
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2 – 6 December 2019, Athens, Greece



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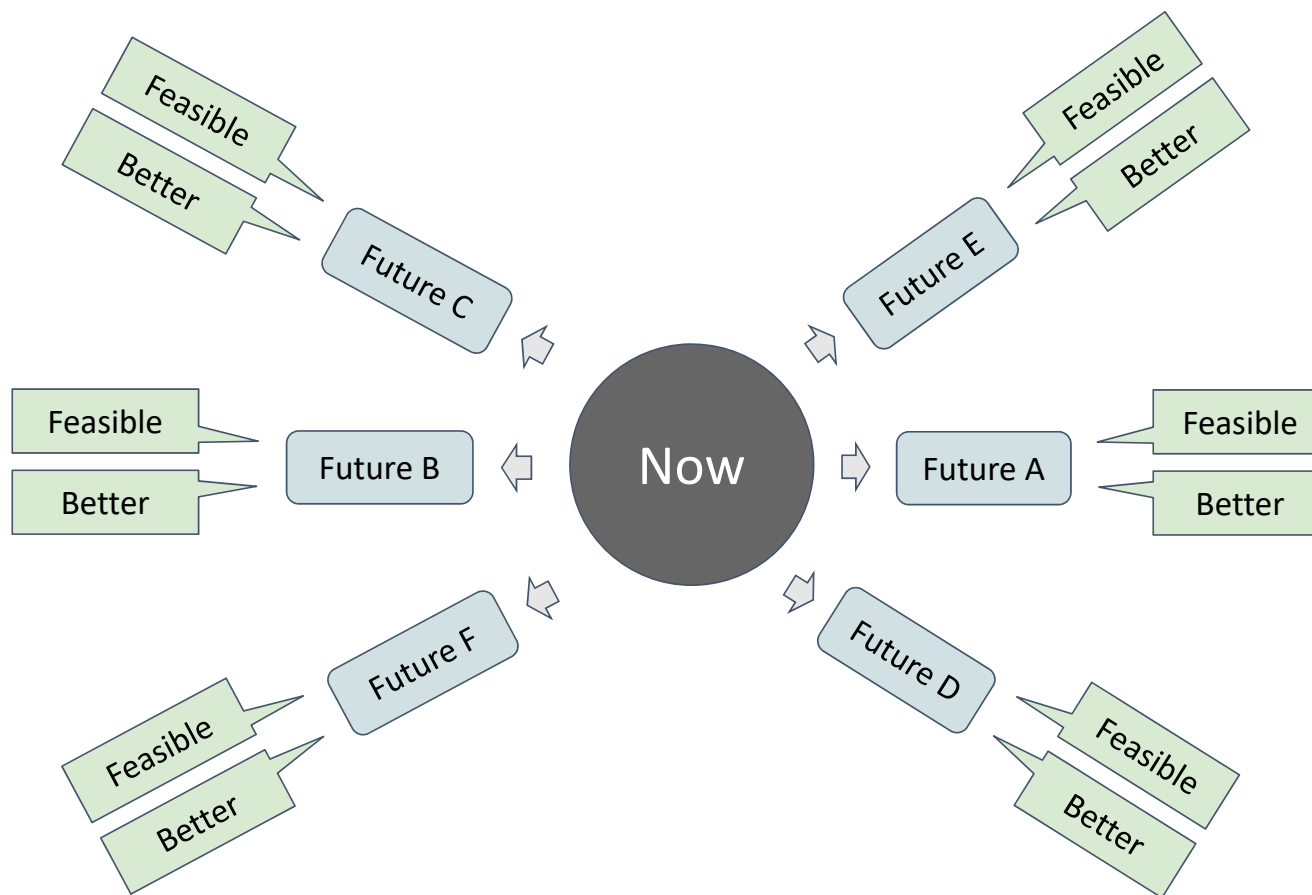
Introduction

TU Delft, CNS/ATM, and Open Science



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Starting Point: Air Traffic Simulation

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SESAR
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In reality



In simulation



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The Research Project

Open Aircraft Performance Modeling: Based
on an Analysis of
Aircraft Surveillance Data

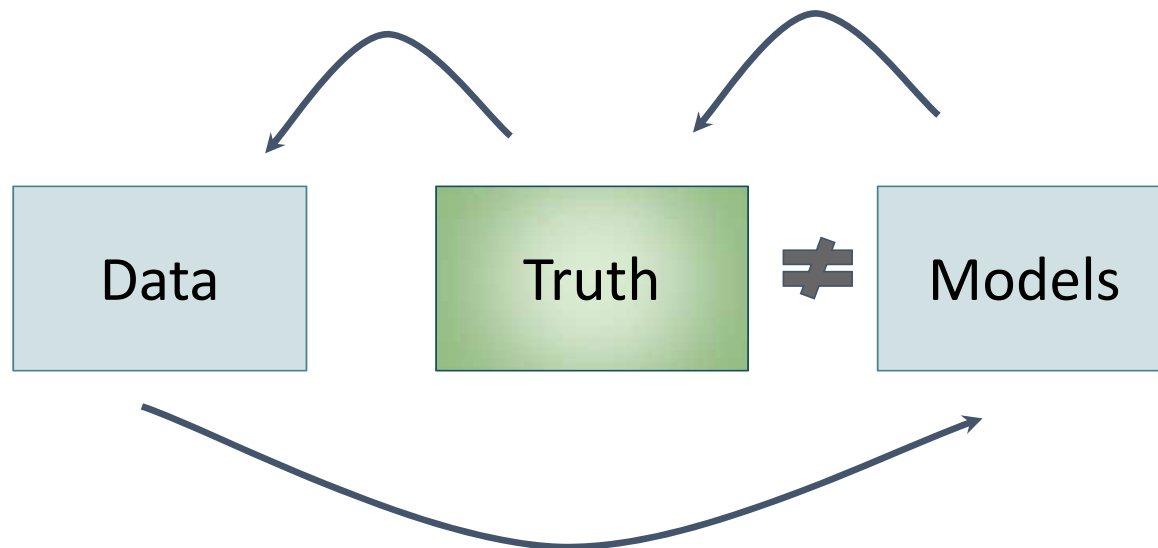


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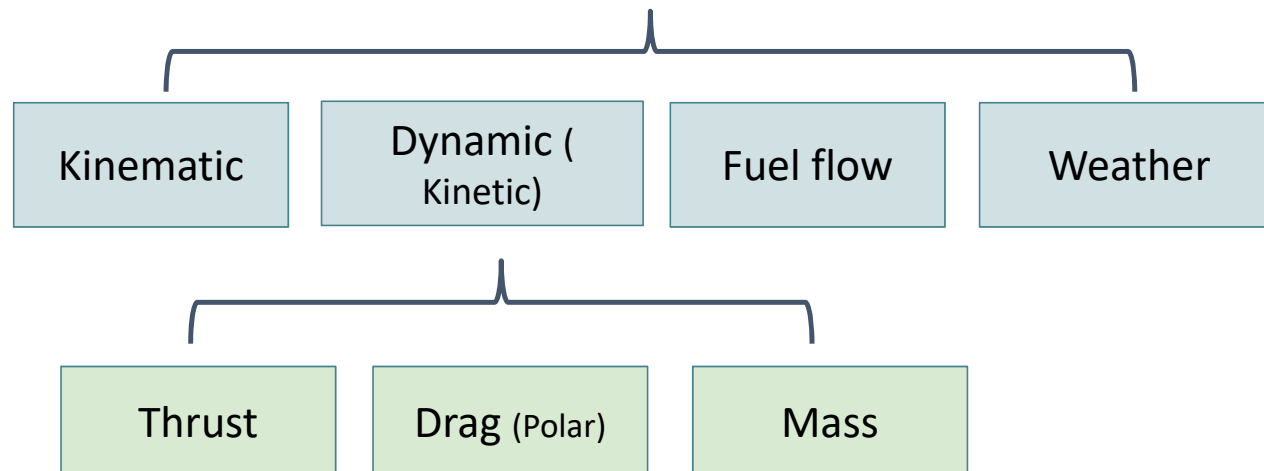


Open Aircraft Performance **Modeling**: Based on an Analysis of Aircraft Surveillance Data





Open Aircraft Performance Modeling: Based on an Analysis of Aircraft Surveillance Data



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Open Aircraft Performance Modeling: Based on an Analysis of Aircraft Surveillance Data

Mode S

ADS-B



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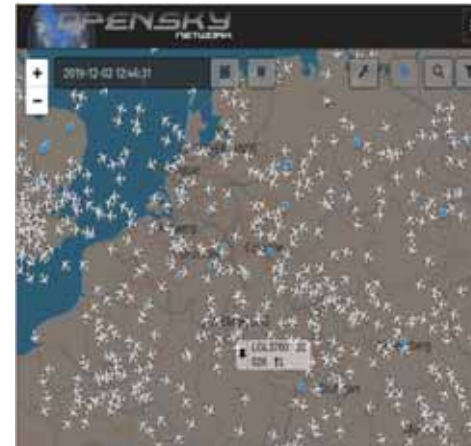
Open Aircraft Performance Modeling: Based on an Analysis of Aircraft Surveillance Data



TU Delft Receiver



FlightRadar24



OpenSky

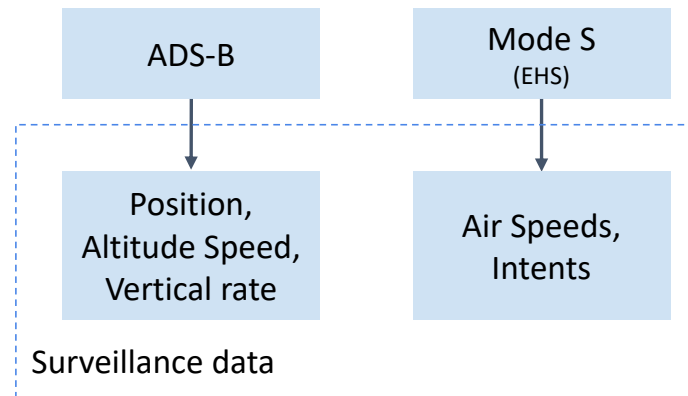


Open Aircraft Performance Modeling: Based on an **Analysis** of Aircraft Surveillance Data



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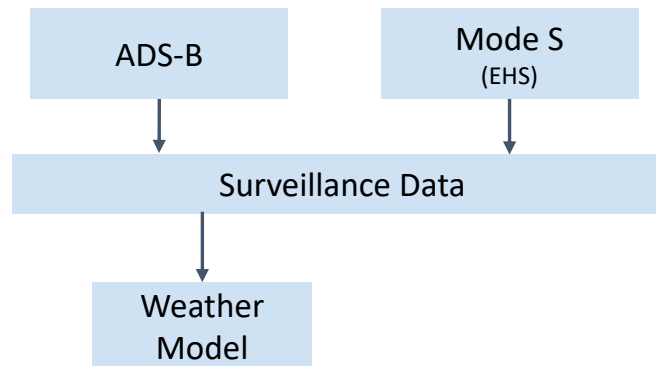


- Sun, J., Vũ, H., Ellerbroek, J. and Hoekstra, J.M., 2019. pyModeS: Decoding Mode-S Surveillance Data for Open Air Transportation Research. IEEE Transactions on Intelligent Transportation Systems.
- Sun, J., Ellerbroek, J. and Hoekstra, J., 2017. Flight extraction and phase identification for large automatic dependent surveillance–broadcast datasets. Journal of Aerospace Information Systems, pp.566-572.



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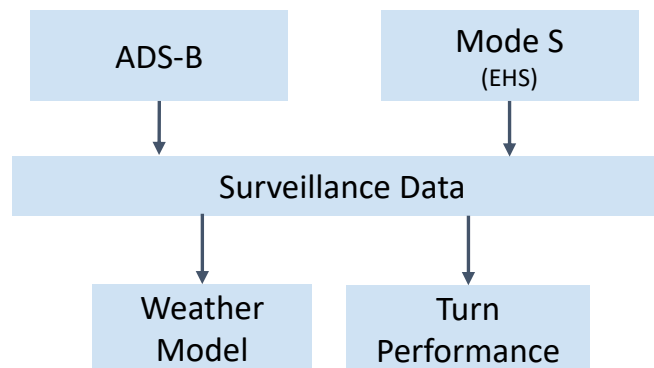


- Sun, J., Vũ, H., Ellerbroek, J. and Hoekstra, J.M., 2018. Weather field reconstruction using aircraft surveillance data and a novel meteo-particle model. PloS one, 13(10), p.e0205029.
- Sun, J., Vũ, H., Ellerbroek, J. and Hoekstra, J., 2017. Ground-based wind field construction from mode-s and ads-b data with a novel gas particle model. *Proceedings of the Seventh SESAR Innovation Days*, 28, p.30th.



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- Sun, J., Vũ, H., Ellerbroek, J. and Hoekstra, J., 2019. Reconstructing Aircraft Turn Manoeuvres for Trajectory Analyses Using ADS-B, *Proceedings of the 9th SESAR Innovation Days*

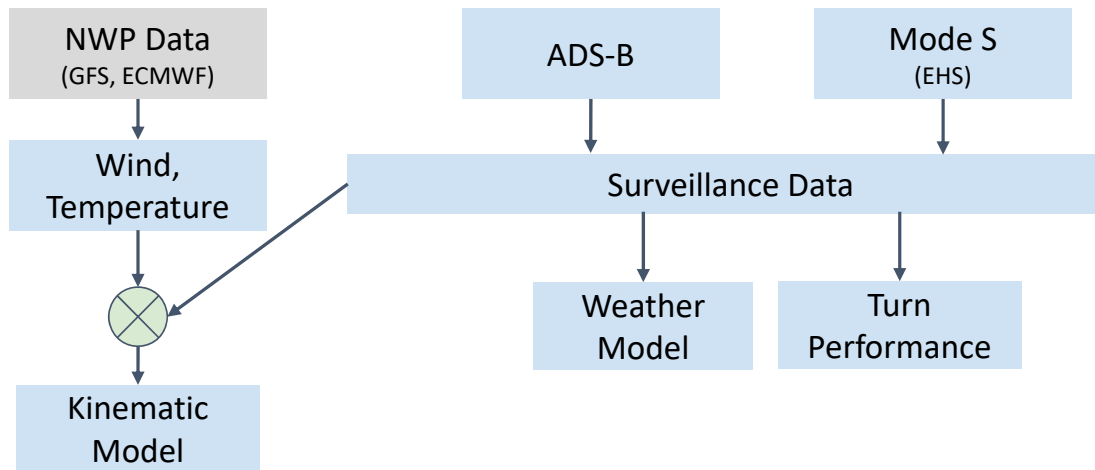


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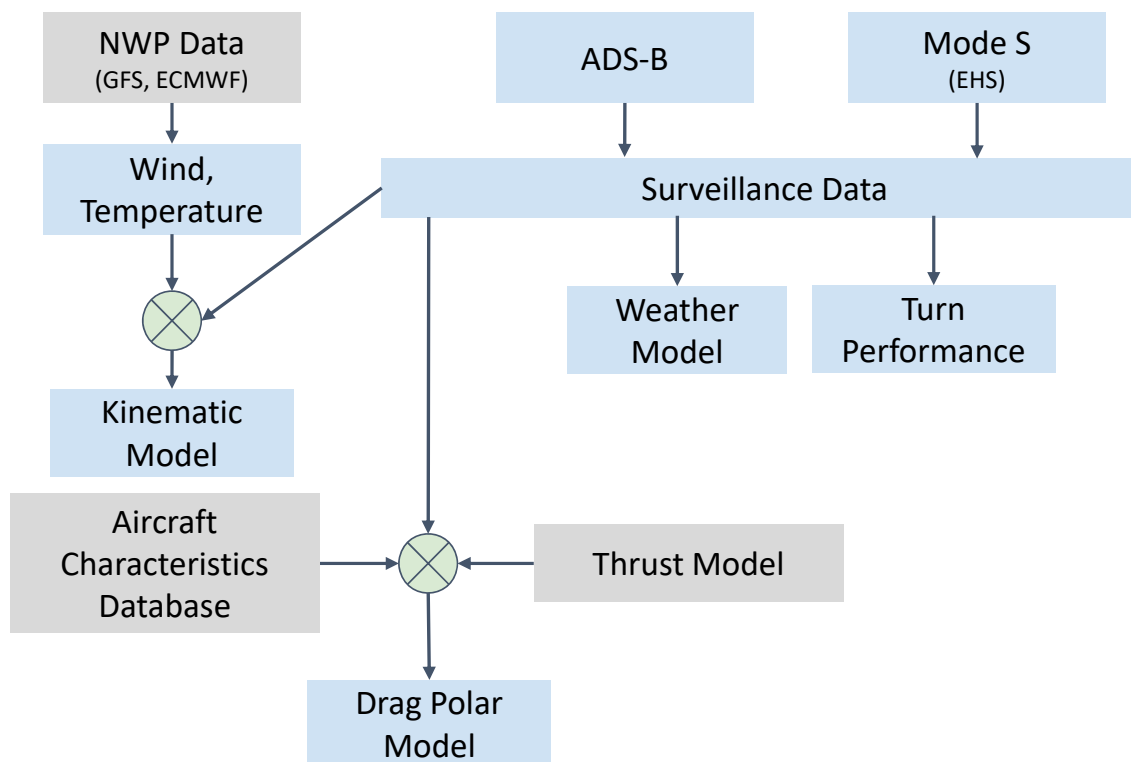
Analysis - Kinematic Model

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- Sun, J., Ellerbroek, J. and Hoekstra, J.M., 2019. WRAP: An open-source kinematic aircraft performance model. Transportation Research Part C: Emerging Technologies, 98, pp.118-138.
- Sun, J., Ellerbroek, J. and Hoekstra, J., 2017, June. Modeling aircraft performance parameters with open ads-b data. In Proceedings of the 12th USA/Europe Air Traffic Management Research and Development Seminar.



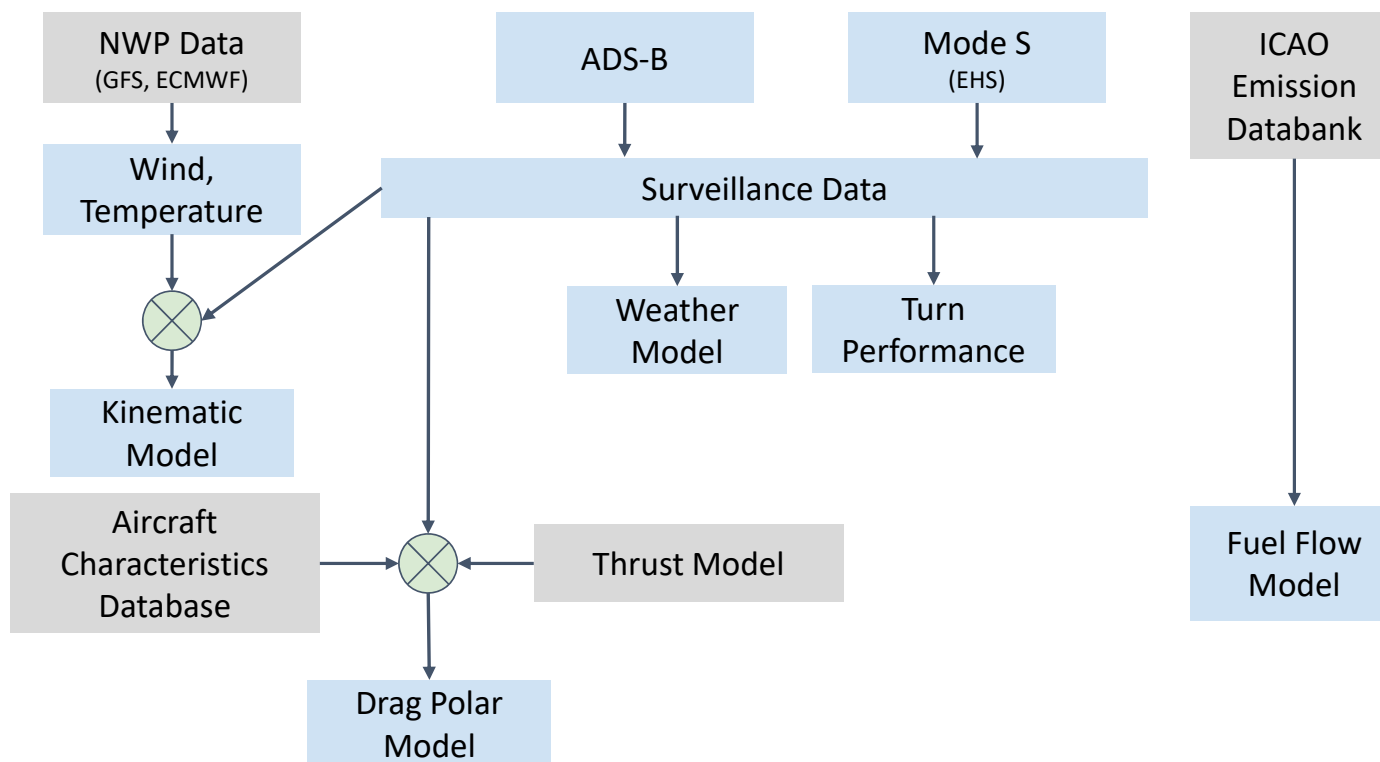


- Sun, J., Hoekstra, J.M. and Ellerbroek, J., 2018. Aircraft drag polar estimation based on a stochastic hierarchical model. In 8th International Conference on Research in Air Transportation.



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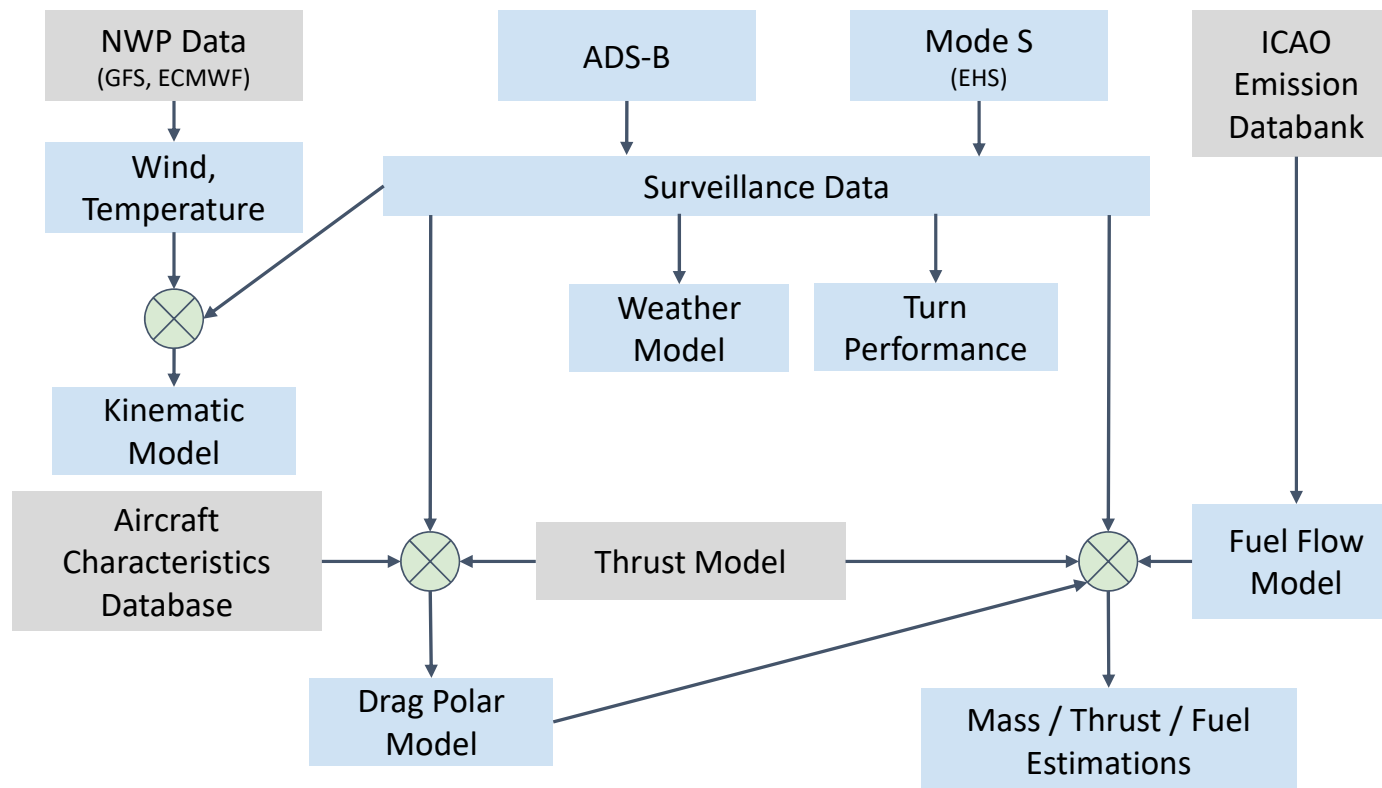


- Sun, J., Ellerbroek, J. and Hoekstra, J.M., 2018. Aircraft initial mass estimation using Bayesian inference method. Transportation Research Part C: Emerging Technologies, 90, pp.59-73.



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- Sun, J., Blom, H.A., Ellerbroek, J. and Hoekstra, J.M., 2018. Aircraft mass and thrust estimation using recursive bayesian method. In 8th International Conference on Research in Air Transportation.
- Sun, J., Ellerbroek, J. and Hoekstra, J., 2016, June. Modeling and inferring aircraft takeoff mass from runway ADS-B data. In 7th International Conference on Research in Air Transportation.



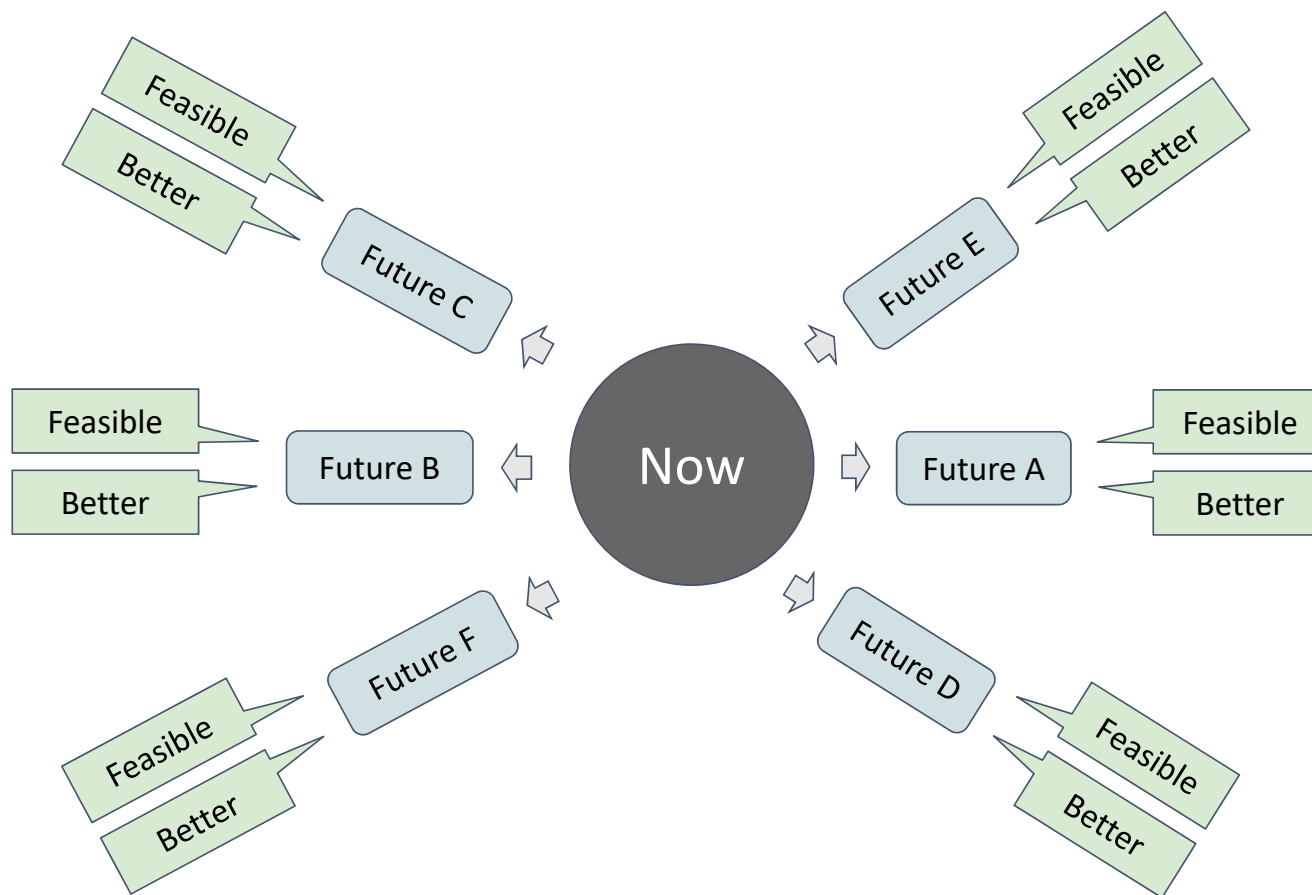
Open Aircraft Performance Modeling: Based on an Analysis of Aircraft Surveillance Data

- [OpenAP](#): A complete set of aircraft performance model and toolkit
- [WRAP](#): An open aircraft kinematic performance model
- [pyModeS](#): An open-source ADS-B and Mode-S decoder
- [Meteo-Particle-Model](#): A weather reconstruction model using ADS-B and Mode-S data
- [BlueSky](#): A large-scale fast-time open air traffic simulator



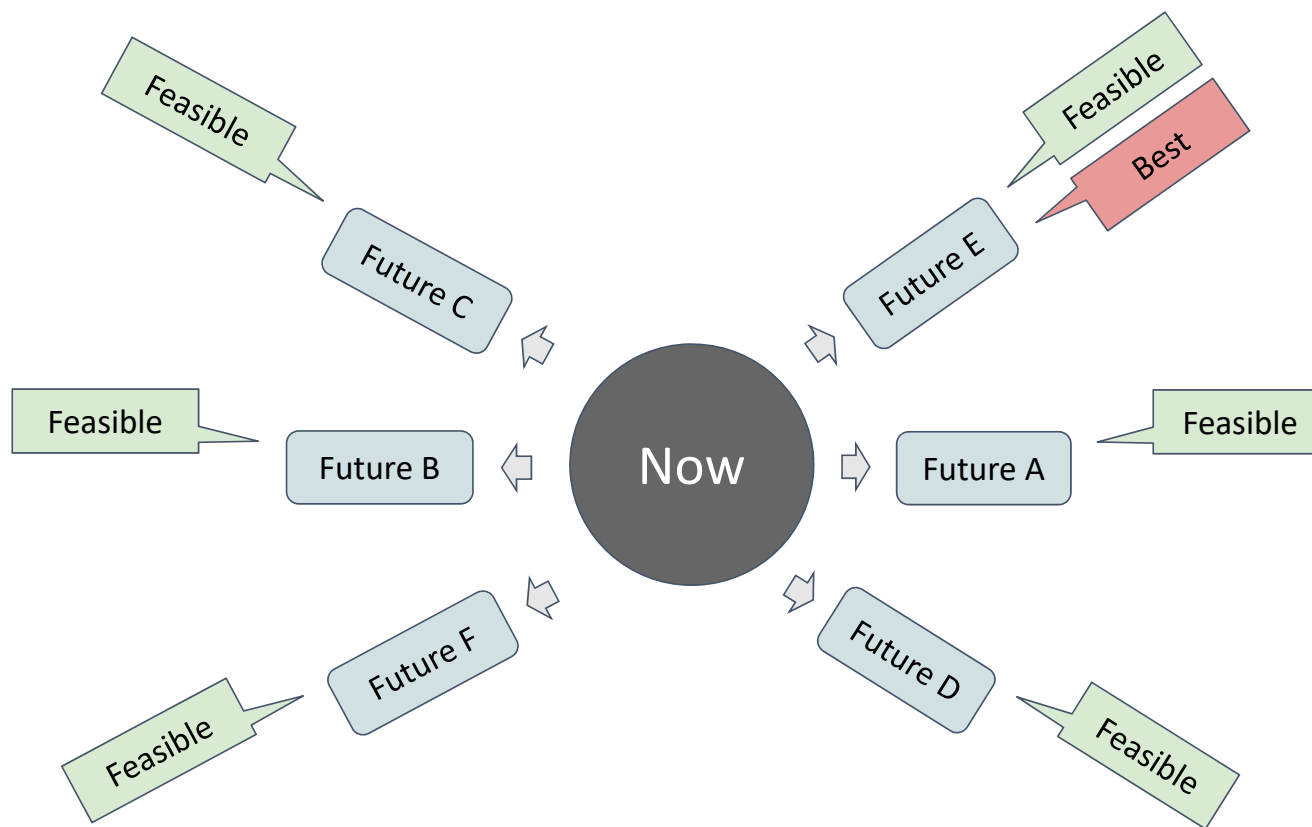
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Thank you!



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2 – 6 December 2019, Athens, Greece



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And now the podium...

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In third place...

Leonid Sedov



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In second place...

Javier Alberto Perez Castan





And the Winner is...

Junzi Sun



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