Climate and weatheR modEls to improve
ATM resilienCE and reduce its impacts

Multi-Aircraft Environmentally-Scored Weather-Resilient Optimised 4D-Trajectories

Nick van den Dungen : NLR team lead – Presenter
Kinanthi Sutopo : NLR team member

FABEC – Research Workshop – Climate change and the role of ATC
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Founding Members
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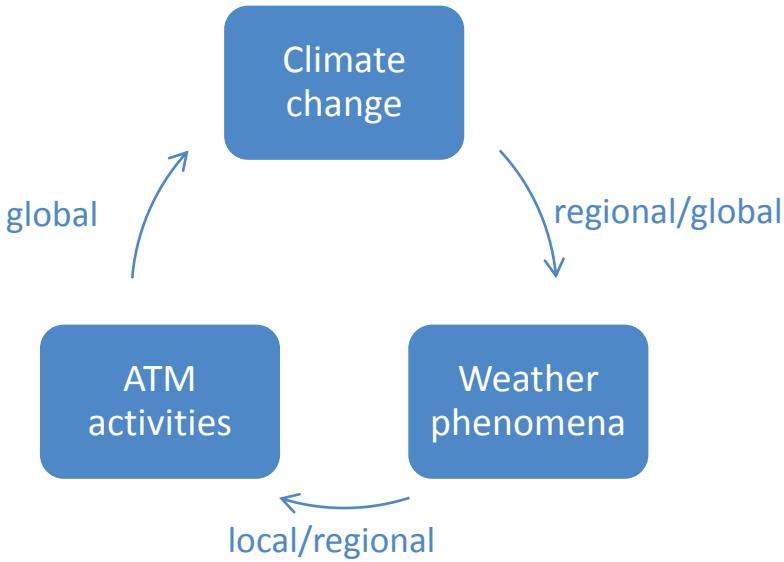
Introduction

- Hazardous weather phenomena, such as convective areas related to **thunderstorms affect ATM operations**
- Storms cause up to **7.5% of total en-route ATFM delays** at network level. → Average en-route ATFM delay due to a storm-affected flight can be around 17-18 minutes per delayed flight. (EUROCONTROL, 2021)
- In 2019, over 1000 Dangerous Thunderstorm Alerts (DTA's) were issued in Italy out of a total of 7372 throughout Europe[1]
- ATM operations impact climate change → from all non-CO_2 emissions **contrail cirrus** have a **significant impact on the climate** (EASA, 2021)
- *"A warmer climate will intensify very wet and very dry weather and climate events and seasons....including monsoons and **mid-latitude storm tracks**"* (IPCC, 2021)



References

[1] https://get.earthnetworks.com/resources/reports/2019-europe-lightning-report

EUROCONTROL (2021), *Climate Change Risks for European Aviation, Summary Report.*

EASA (2021), *Updated analysis of the non-CO2 climate impacts of aviation and potential policy measures pursuant to EU Emissions Trading System Directive Article 30(4).* Brussels, European Commission.

IPCC (2021), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

CREATE Project Overview

Project type: SESAR exploratory research → TRL1/2

Main project goal: develop a concept of operations to improve the weather resilience of ATM operations and reduce its environmental/climate impacts.

Consortium:

Coordinator		Università degli Studi di Napoli Parthenope (UNIPARTH)
		Royal Netherlands Aerospace Centre (NLR)
		Universitat Politècnica de Catalunya - Barcelona Tech (UPC)
		Centro Italiano Ricerche Aerospaziali (CIRA)
		ARIANET SRL
		Ilmatieteen Laitos (Finish Meteorlogical Institute, FMI)
		Institute for Sustainable Society and Innovation (ISSNOVA)

ConOps design elements

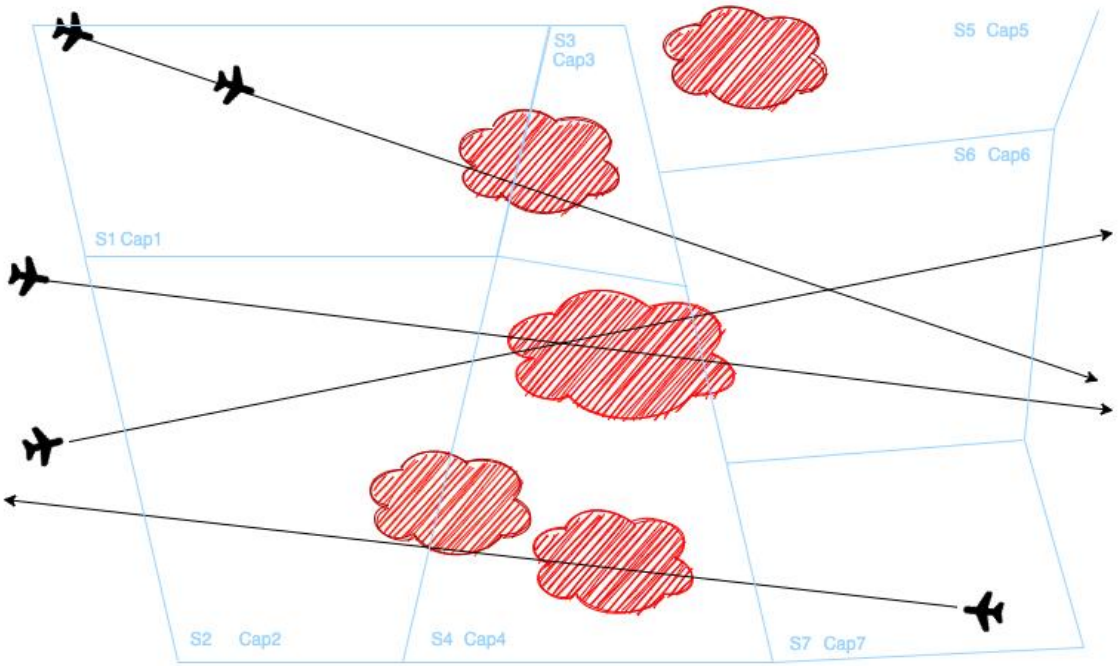
Within CREATE, all of the below shall be integrated in the ATM network planning and execution process, **to mitigate planning disturbances and unplanned delays** caused by manual tactical ATC intervention **during severe weather scenarios**, whilst **minimising the climate and local air quality impacts of the ATM operations**.

- **Multiple-aircraft** propose candidate optimised 4D-trajectories
- **Numerical ensemble weather forecasting (EWF)** is used for tactical trajectory replanning during flight
- **Environmental score assessment** is used to evaluate all candidate trajectories
- **ATC-driven demand-capacity-balancing (DCB) decision-making process** determines global optimum of the candidate trajectories

ConOps development (1/4)

Imagine an arbitrary scenario with multiple airspace sectors and multiple aircraft;

- **Thunderstorms** propagate along the initially planned flight paths
- Without tactical trajectory optimisation, ATC would need to tactically intervene and guide aircraft around thunderstorms in coordination with the flight crew.



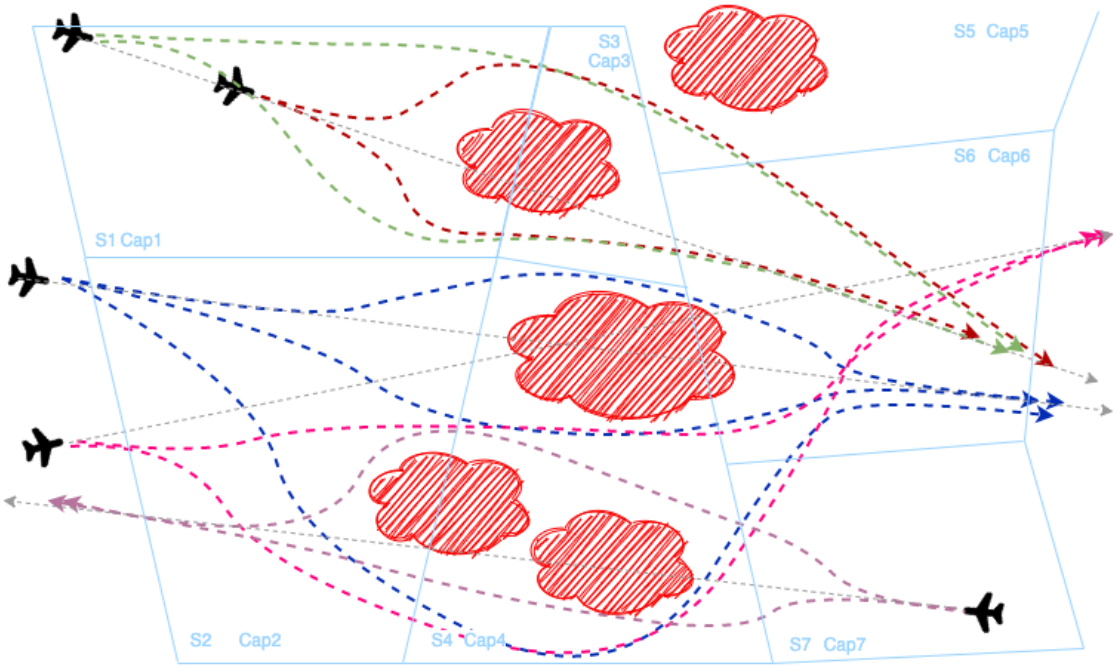
Red areas are thunderstorm-related no-fly-zones (NFZ)

- ➢ This gives unplanned delays in the ATM network
- ➢ This has potential snowballing effect on delays further downstream in the network

ConOps development (2/4)

With the CREATE framework:

- **Ensemble numerical weather predictions** from ground stations uplink meteo forecast to AU's
- When thunderstorm NFZ is detected, optimised **all aircraft propose candidate trajectories** are based on e.g.;
  - Minimum fuel burn
  - Minimum delay
  - Minimum environmental impact



Dashed lines are candidate optimised trajectories

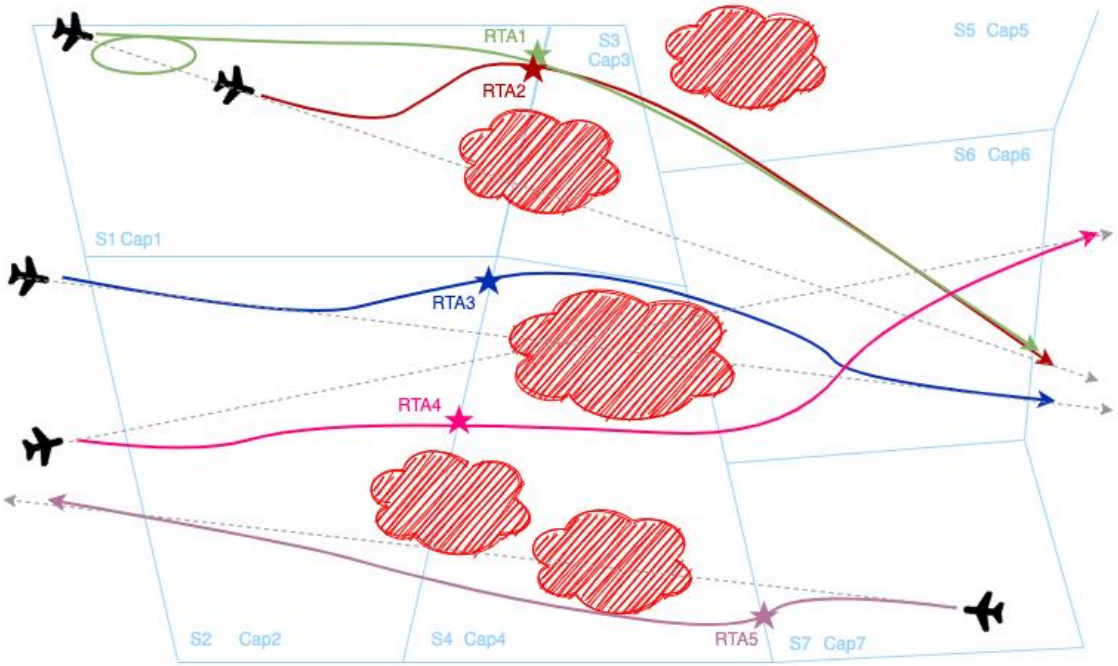
ConOps development (3/4)

With the CREATE framework:

- A centralised demand-capacity balancing (DCB) decision-making component governed by ATC determines global optimum of all candidate trajectories

This includes:

- Environmental scores assessment
  - CO_2
  - NO_x
  - Lagrangian particle decomposition of emissions → LAQ
- Sector load-balancing

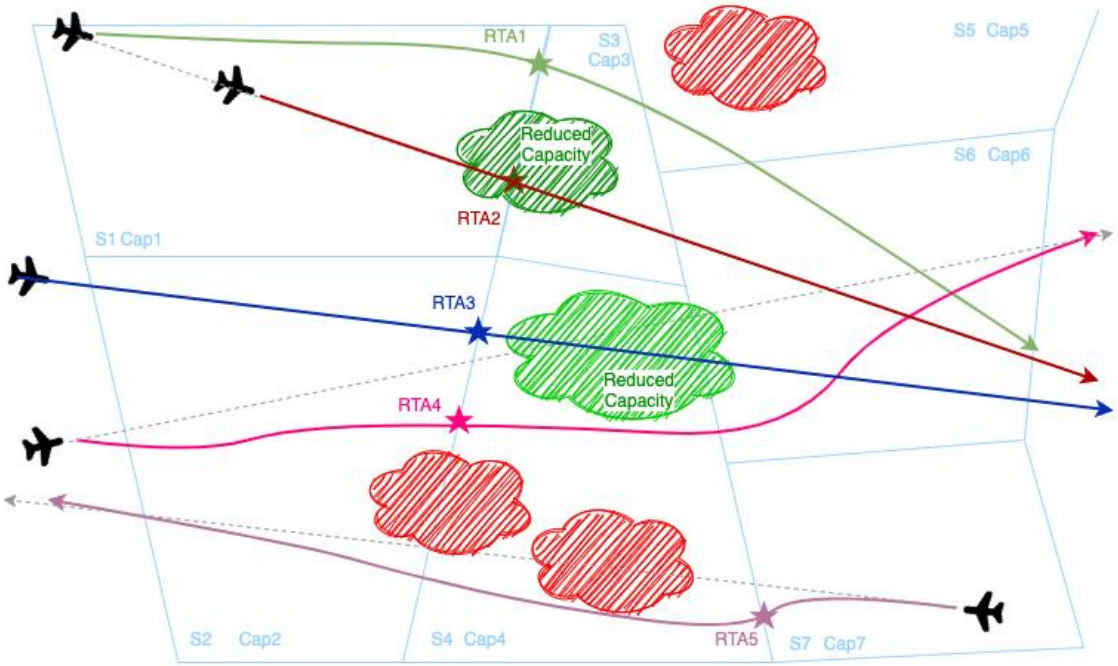


ATC-driven DCB decision-making process selects global optimum of all trajectories

ConOps development (4/4)

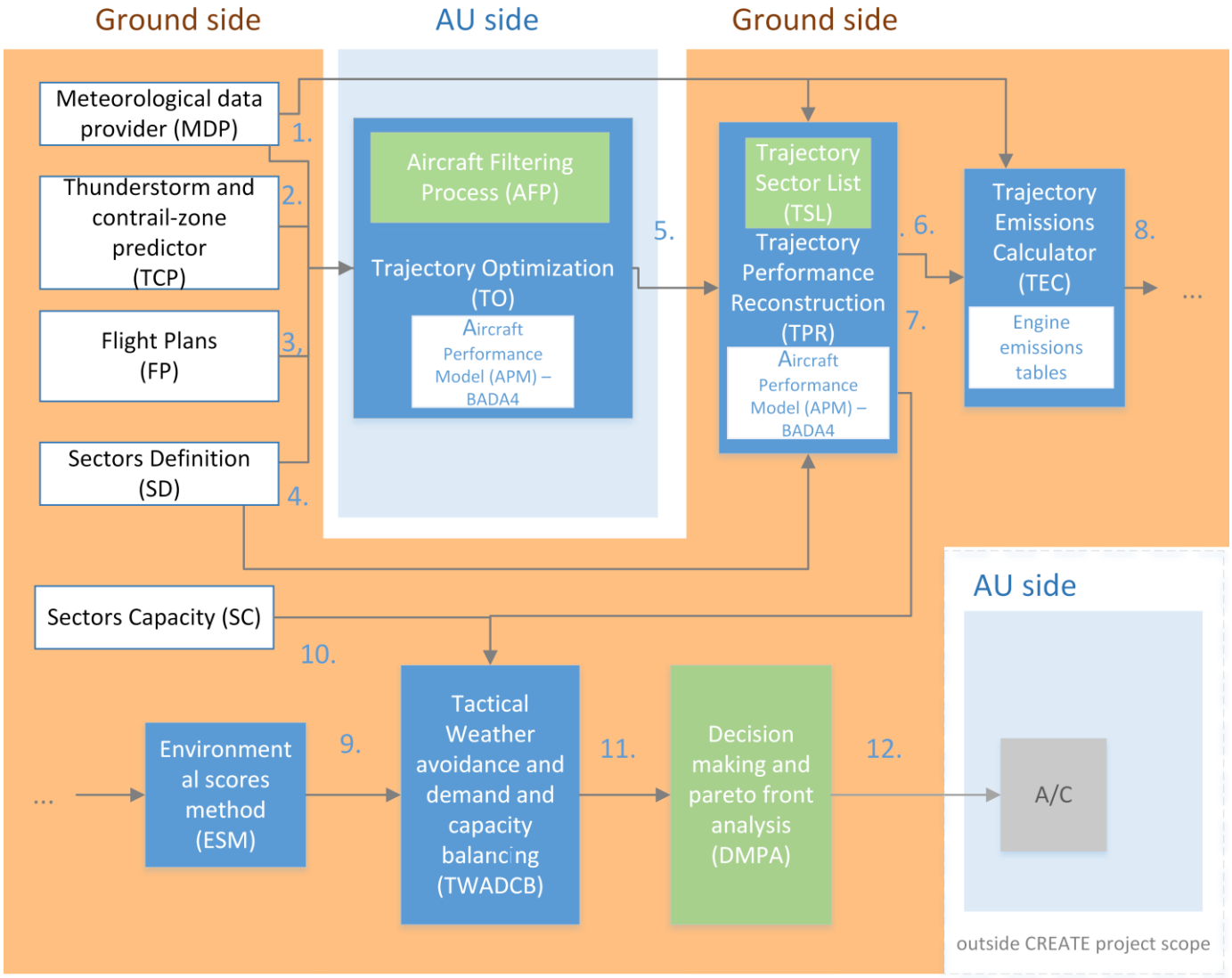
With the CREATE framework:

- **Climate sensitive zones**, related to **contrail cirrus formation**, are predicted as well.
- These regions can be easily evaded via **flight level changes**, not only lateral evasion.



Green climate-sensitive zones (contrail formation) can be evaded via flight-level changes as well

CREATE framework

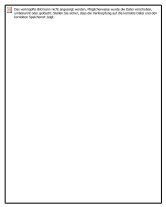


Next steps and Questions

Next steps in the research project

- Integrate all models into a computational framework
- Initial validations via fast-time simulations
- Demonstrate effectiveness of framework for two use-cases
  - En-Route → North Atlantic
  - TMA → Naples Capodichino airspace

For further information, please contact:



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NLR - Royal Netherlands Aerospace Centre

ir. N.H.M. (Nick) van den Dungen
R&D Engineer / Consultant
Air Traffic Management & Airports
Aerospace Operations
e) nick.van.den.dungen@nlr.nl
i) www.nlr.org

To keep posted, follow CREATE on LinkedIn:

https://www.linkedin.com/company/createproject/

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Thank you very much for your attention!

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