



# Exploring Strategies for minimising persistent warming contrails

8 November 2023

Siân Andrews / NATS & Brice Bergantz / Airbus

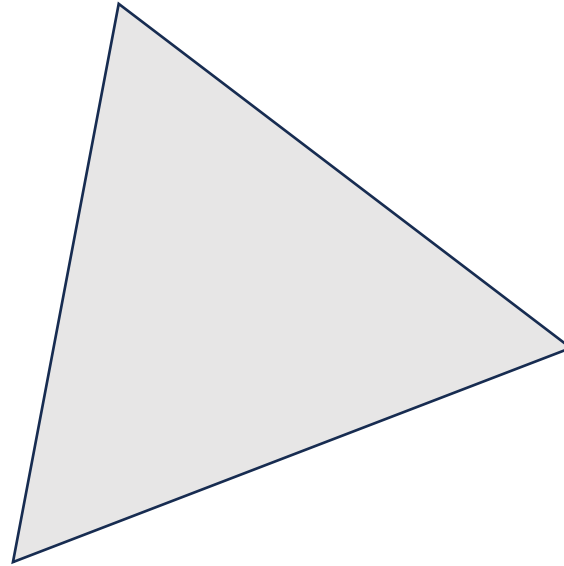


This work receives funding from UK Research and Innovation [10091271]

# What can be done to minimise warming contrails?

- Contrails avoidance
- "Big Hits" contrails minimisation
- Climate optimised trajectories
- Formation flights ?

## Operations




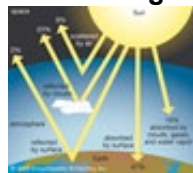
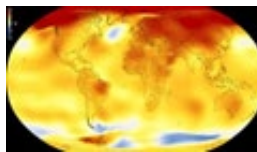

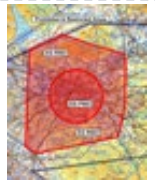


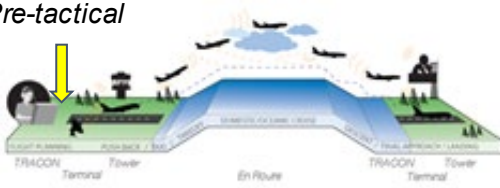
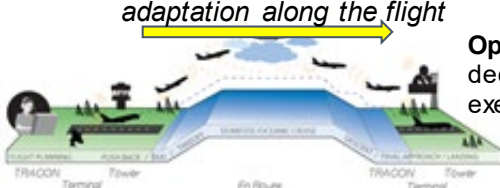
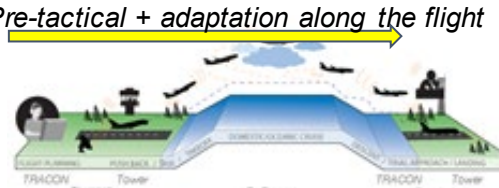

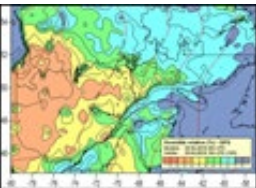
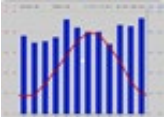
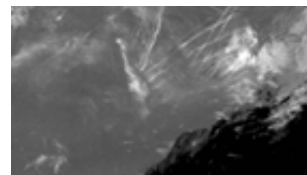
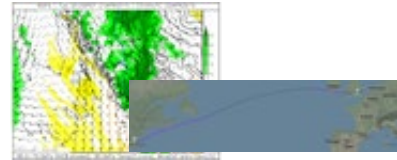
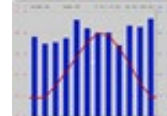



## Technology

- Low soot emission combustors
- Alternative powerplant architecture?
- A/C Aerodynamic optimisation?

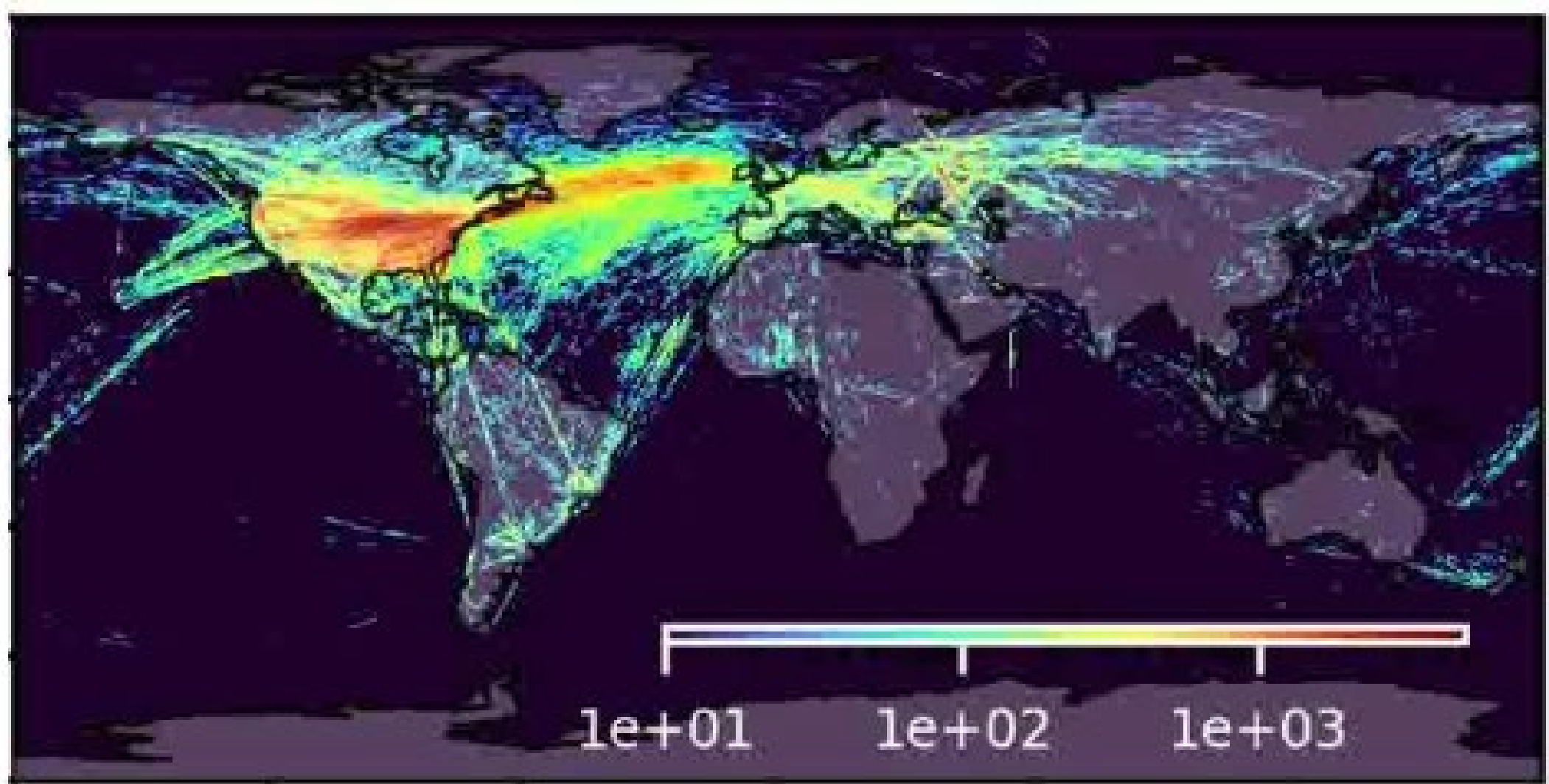
## Alternative fuels

- Low-aromatic / low sulfur fuels
- SAFs
- Hydrogen?

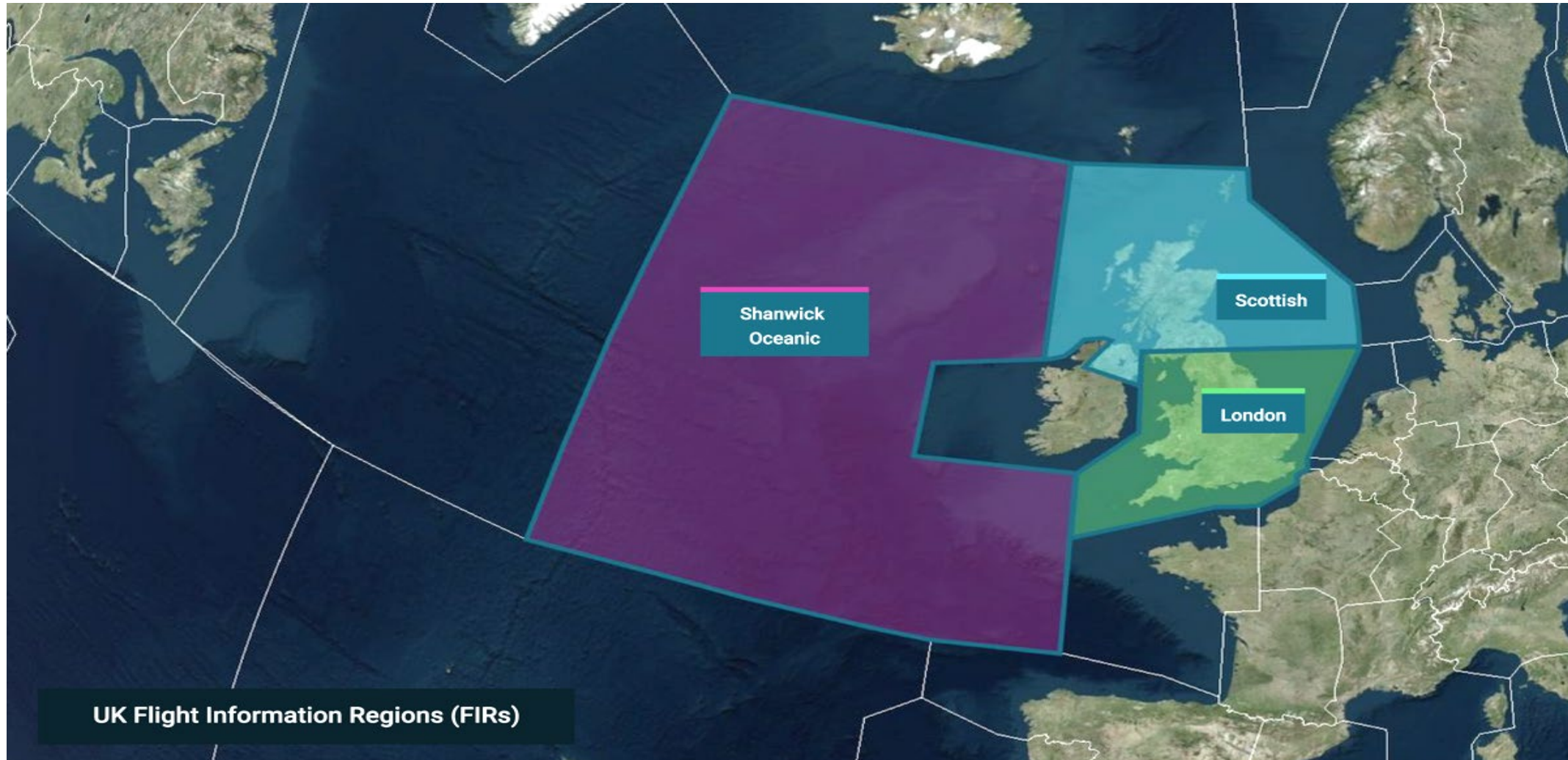
# CONOPS options to be assessed in CICONIA project

	Contrails focus only		All CO2 and Non-CO2 consideration	
<b>Mitigation objective</b>	<p><b>Persistent contrails formation</b></p>  <p><b>Option 1:</b> night flight ISSR avoidance <b>Option 2:</b> night flight persistent contrails avoidance</p>	<p><b>Radiative forcing effect</b></p>  <p><b>Option 3:</b> night time persistent contrails avoidance <b>Option 4:</b> Big Hits contrails avoidance</p>	 <p><b>Option 6:</b> Climate (CO2 and Non-CO2) optimisation</p>	
<b>Incentive for action</b>	 <p><b>Option 1:</b> Flight path restriction</p>	 <p><b>Option 2:</b> Air space restriction</p>	 <p><b>Option 3:</b> airspace environmental taxation or positive incentive through a form of discount</p>	 <p><b>Option 4:</b> Market based measure (EU ETS / CORSIA) CO2e method</p>
<b>Timeframe for decision making</b>	<p><i>Pre-tactical</i></p>  <p><b>Option 1:</b> Pre-tactical / flight planning</p>	<p><i>adaptation along the flight</i></p>  <p><b>Option 2:</b> tactical decision during flight execution</p>	<p><i>Pre-tactical + adaptation along the flight</i></p>  <p><b>Option 3:</b> Pre-actical / flight planning <u>and</u> tactical decision during flight execution</p>	
<b>Operational decision driver</b>	 <p><b>Option 1:</b> Observations or measurements</p>	 <p><b>Option 2:</b> Weather forecast</p>	 <p><b>Option 3:</b> Statistics or simplified models</p>	
<b>Post-flight mean of compliance</b>	 <p><b>Option 1:</b> Post-flight analysis of observations or measurements</p>	 <p><b>Option 2:</b> Based on weather forecast or weather reanalysis / post-flight computations using flight track data</p>	 <p><b>Option 3:</b> Statistics or simplified models</p>	
<b>Main optimization decision holder</b>	 <p><b>Option 1:</b> Optimisation choice mainly let to the discretion of each individual airline</p>	 <p><b>Option 2:</b> Optimisation choice mainly in the hands of Air Traffic Controllers</p>	 <p><b>Option 3:</b> Multi-stakeholders (ATM, ATC(s), airline(s)) decision making for climate impact reduction at fleet level</p>	

# NATS Focus on North Atlantic



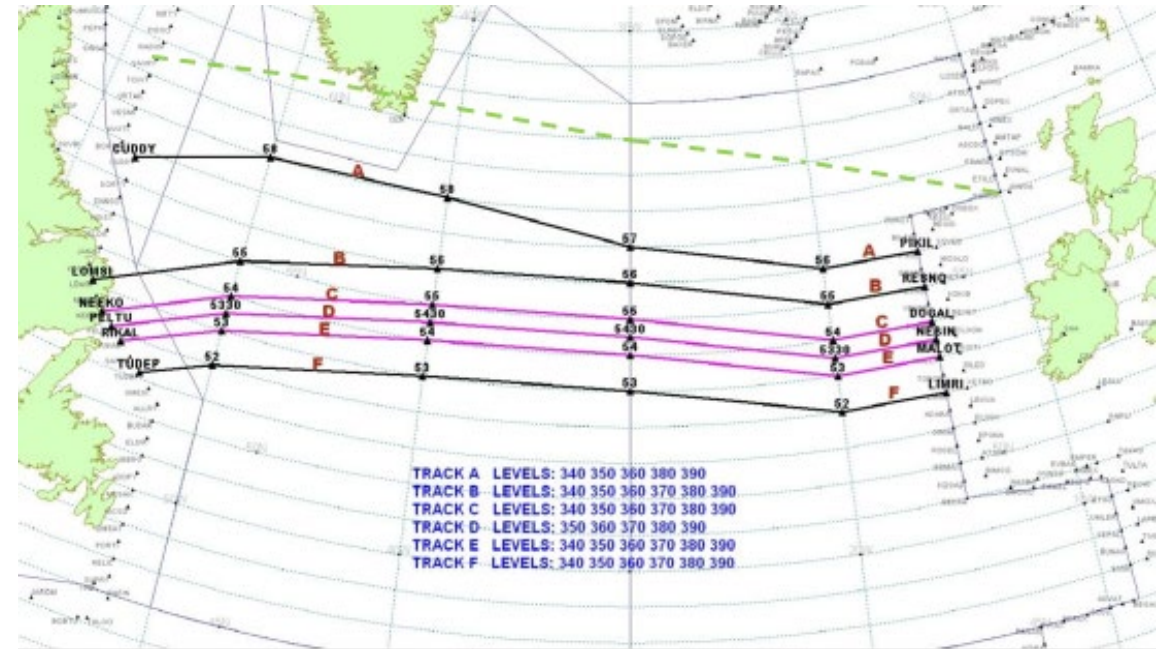
# Shanwick trial options





# Trial options – Alternate planned flight profiles

- Aircraft operator and ANSP collaborate to block a small number of flight levels linked to flight plan
- Final decision prior to aircraft reaching oceanic airspace confirms a single trajectory and releases blocked levels
- *Concept tested during TOPFLIGHT project*

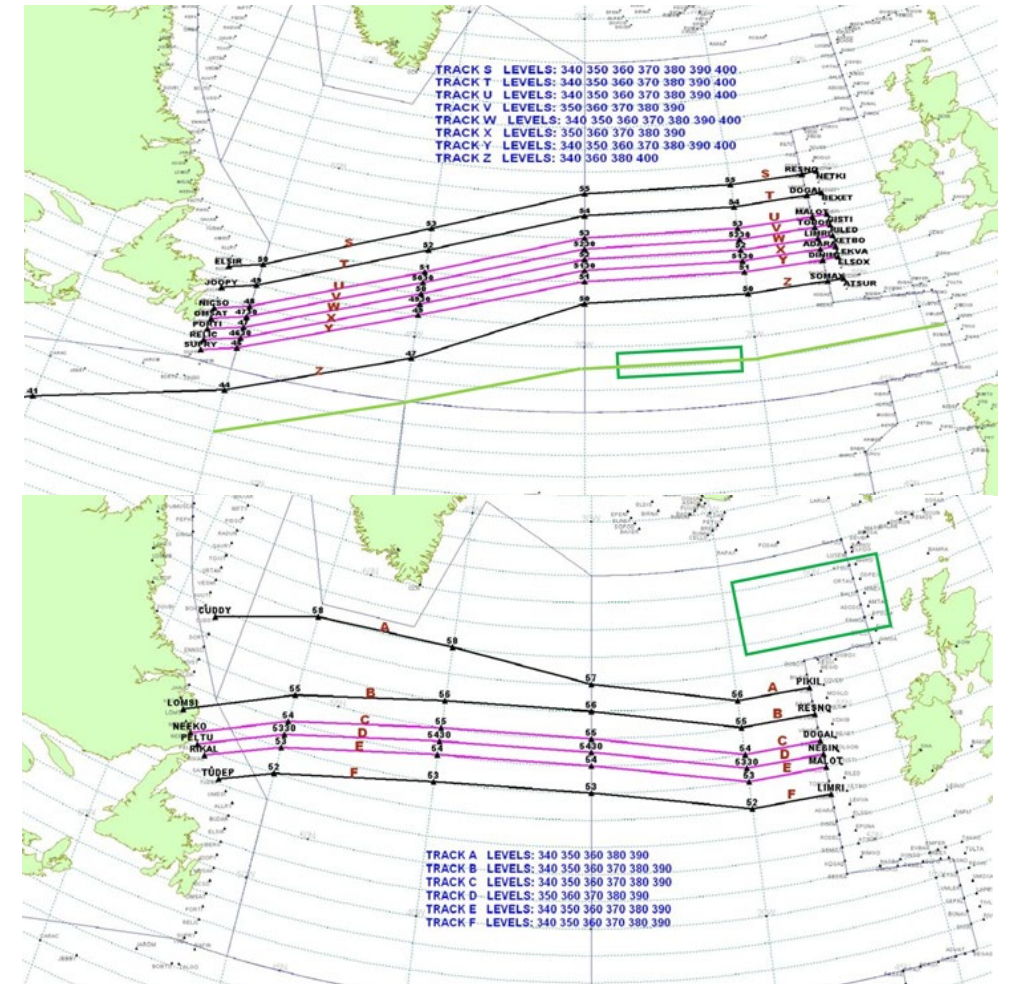


<https://aviationbenefits.org/case-studies/sesar-and-topflight/>

# Trial options – Reservation Route/Area

- ANSP block a defined airspace region around a planned route, or a larger block of airspace to allow flight crew adjust trajectories independently within reservation
- *Reservation concept tested during Airbus fello'fly project*

<https://www.airbus.com/en/newsroom/stories/2020-09-how-a-fellofly-flight-will-actually-work>





# CICONIA Trials



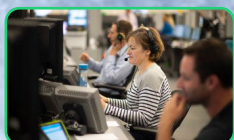
Oceanic



Continental



Airline-led



ANSP-led



Air France



Swiss



Easyjet



NATS



MUAC



Additional partners

# Airline Trials

A photograph of an airplane wing and tail against a sunset sky with many white contrails.

- Avoidance strategies of High climate impact risk areas
- Objectives
  - Operational feasibility
  - Understanding timings
  - Effect on fuel burn, non-CO<sub>2</sub> emissions, operational cost, network effects and passenger journey impact

# Airline Trials

## Swiss and Air France

- Domestic and Oceanic environments to be addressed
- Avoidance in flight planning and in flight execution
- **Desktop exercise** – hypothetical flights, using Flight planning tools
- **Shadow mode trials** – actual flights investigated parallel to live operations, using Flight planning tools and cockpit FMS
- **Live Trials** – actual flights investigated with dispatchers and/or cockpit crew involvement and actual avoidance actions taken (or not), in flight planning and/or flight execution



# Airline Trials – Easyjet

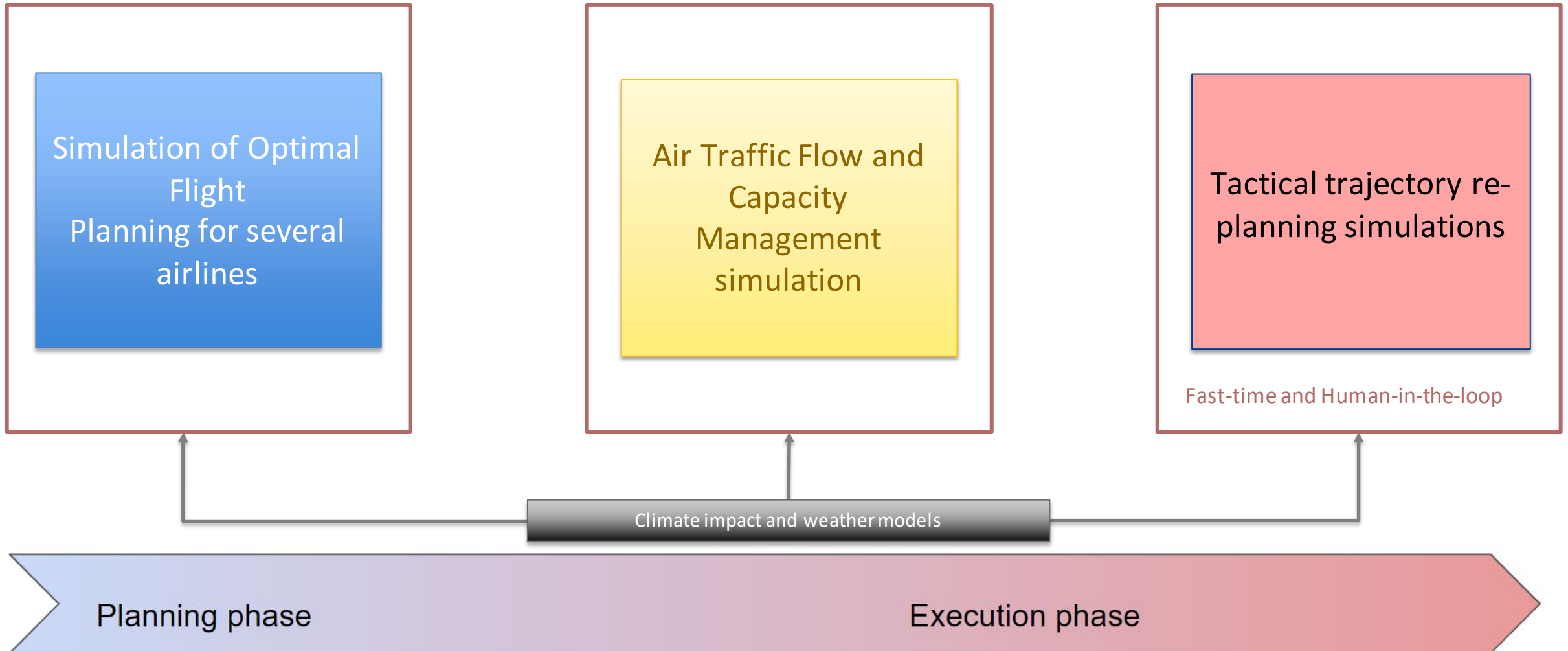
- Shadow mode trials for all flights
  - Analysis to define future live trials
  - Analysis of potential routes
- Live flight trials
  - targeting routes, estimated ~10 flights per day (tbc)
- Final trials
  - Continued optimisation
  - Assessment of flight delays to mitigate contrails
  - Assessment of forecast vs actual weather data

# EUROCONTROL MUAC Trials

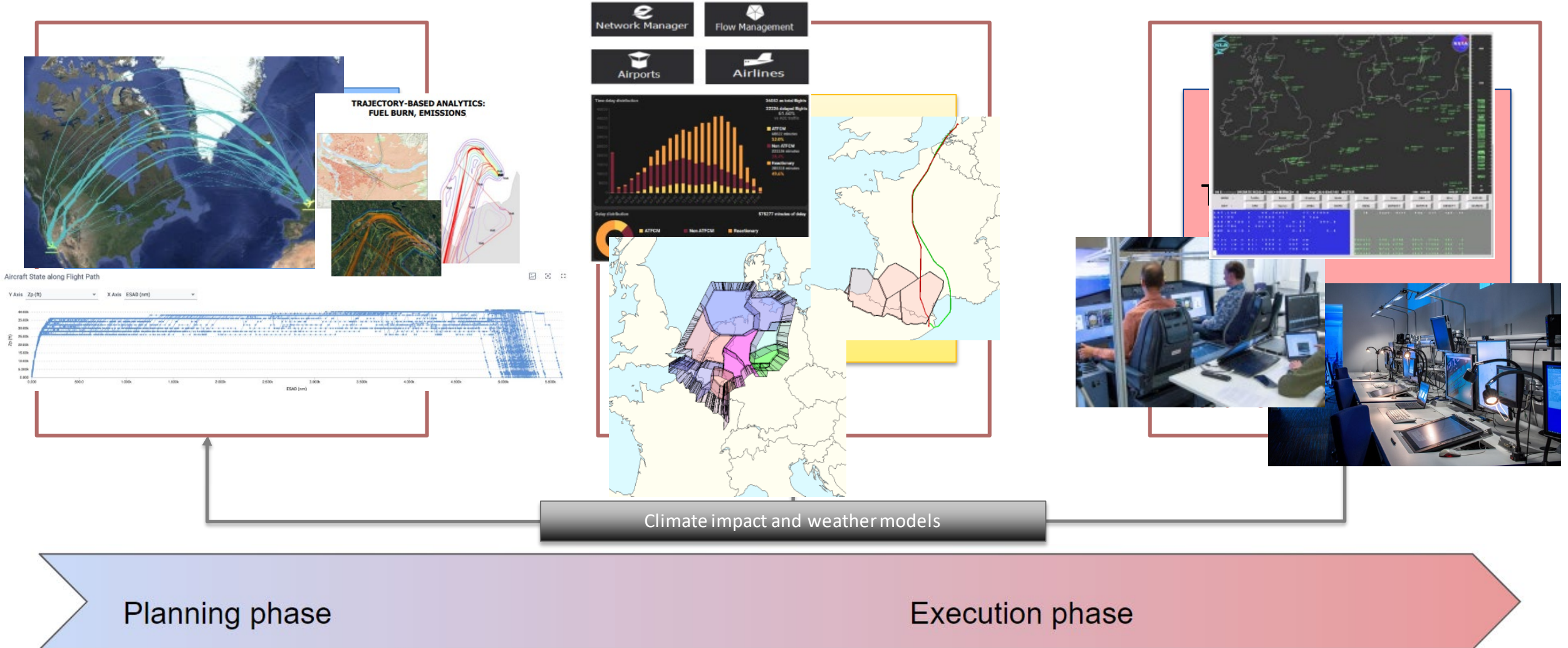
- Focus is on mixed operational concepts of pre-tactical planning with tactical corrections
- Several different trial types
  - Test the pre-tactical concept
  - Tactically correct differences between forecast and nowcast weather
  - Tactically involve all Aircraft Operators in blocking FLs of contrail prone areas



# CICONIA simulation workflow



# CICONIA simulation workflow



# Concluding remarks

- Operational Mitigation is being explored in CICONIA
  - Airline-led action in the planning phase
  - ANSP-led and tactical options
- North Atlantic is a key area to take action
- Understand Avoidance at scale
  - Impact on the Network
  - Impact on the Airspace Users
- Contrail Management is possible