CREATE-SOL-3 : CO2 and non-CO2 balanced Environmental Scores Module (ESM)

Environmental Performance Metric for ATM operations

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Final exploitation event

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Background

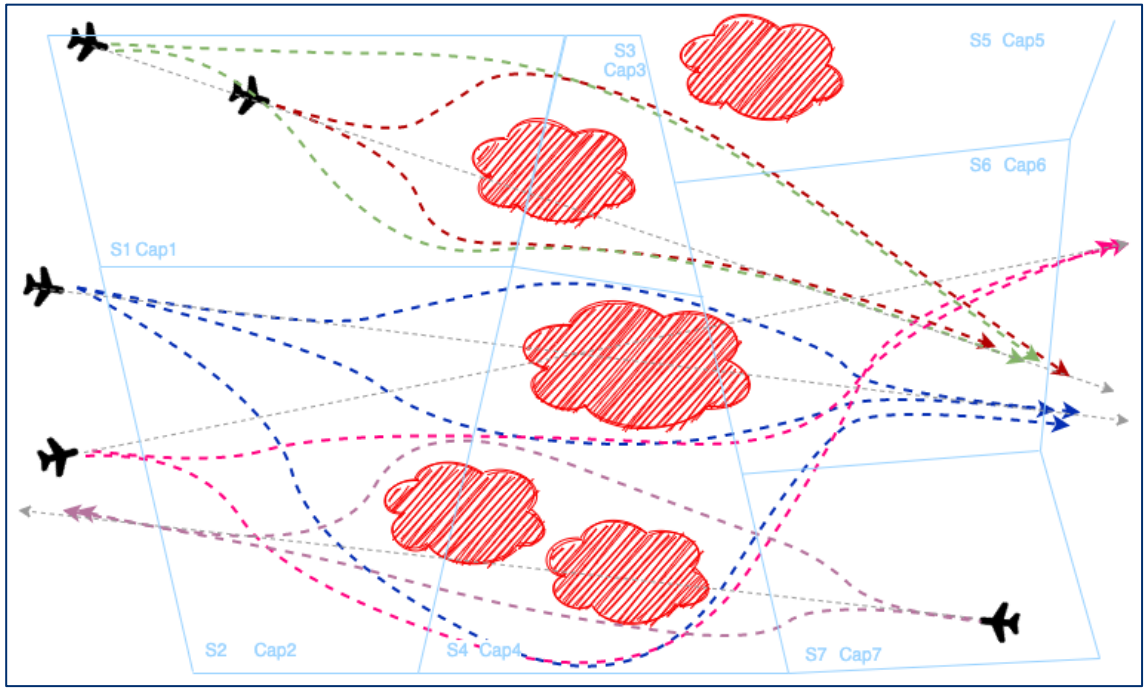
- In the flight plan generation and optimisation process it is aimed to find a trajectory which meets all ATM constraints, but is as well environmentally friendly.

- The CREATE project proposes a solution (CREATE-SOL-3) which address both CO_2 and non-CO_2 effects during the en-route flight phase.

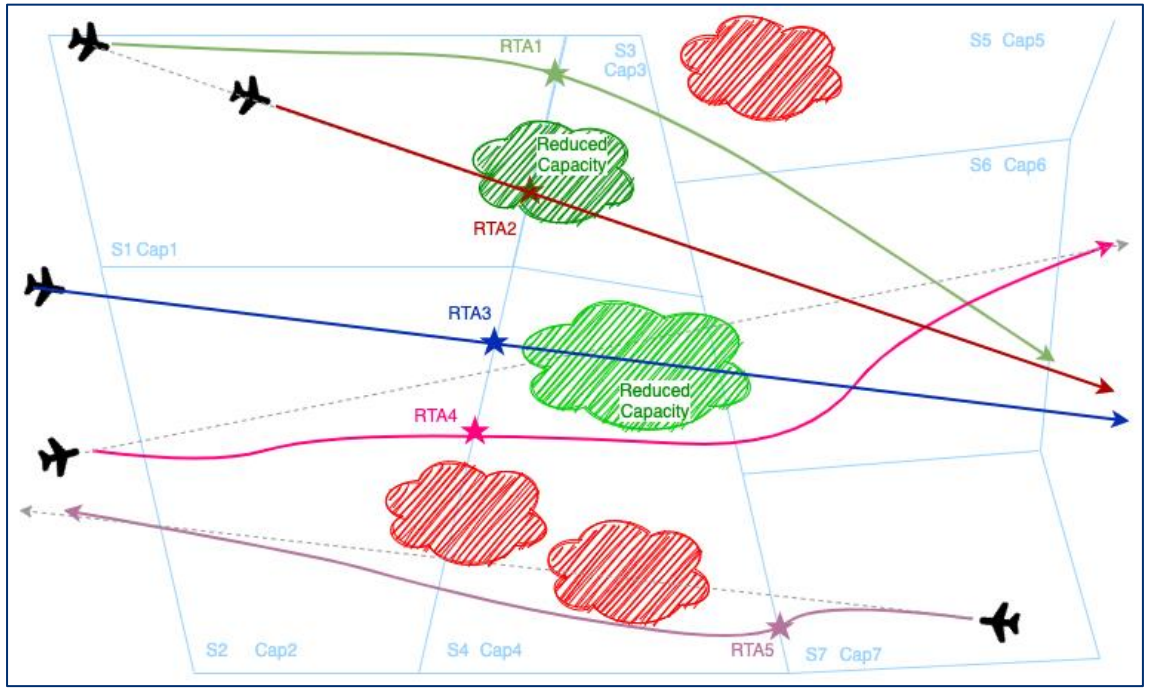
- The non-CO_2 effects include
  - H_2O emissions
  - No_x emissions
  - Contrail formation

- The solution will be used to evaluate the “greenness” of aircraft 4D

Concept of Operations



Generation of Candidate Trajectories (CT)



Selection of most suitable trajectories. Selection is done based on ESM and ATM constraints such as airspace capacity.

CREATE-SOL-3 was applied to North Atlantic use-case in simulation experiment, because this is where there is a large probability of large contrail sensitive area occurrence.

ESM is used here,
each CT has a ESM score

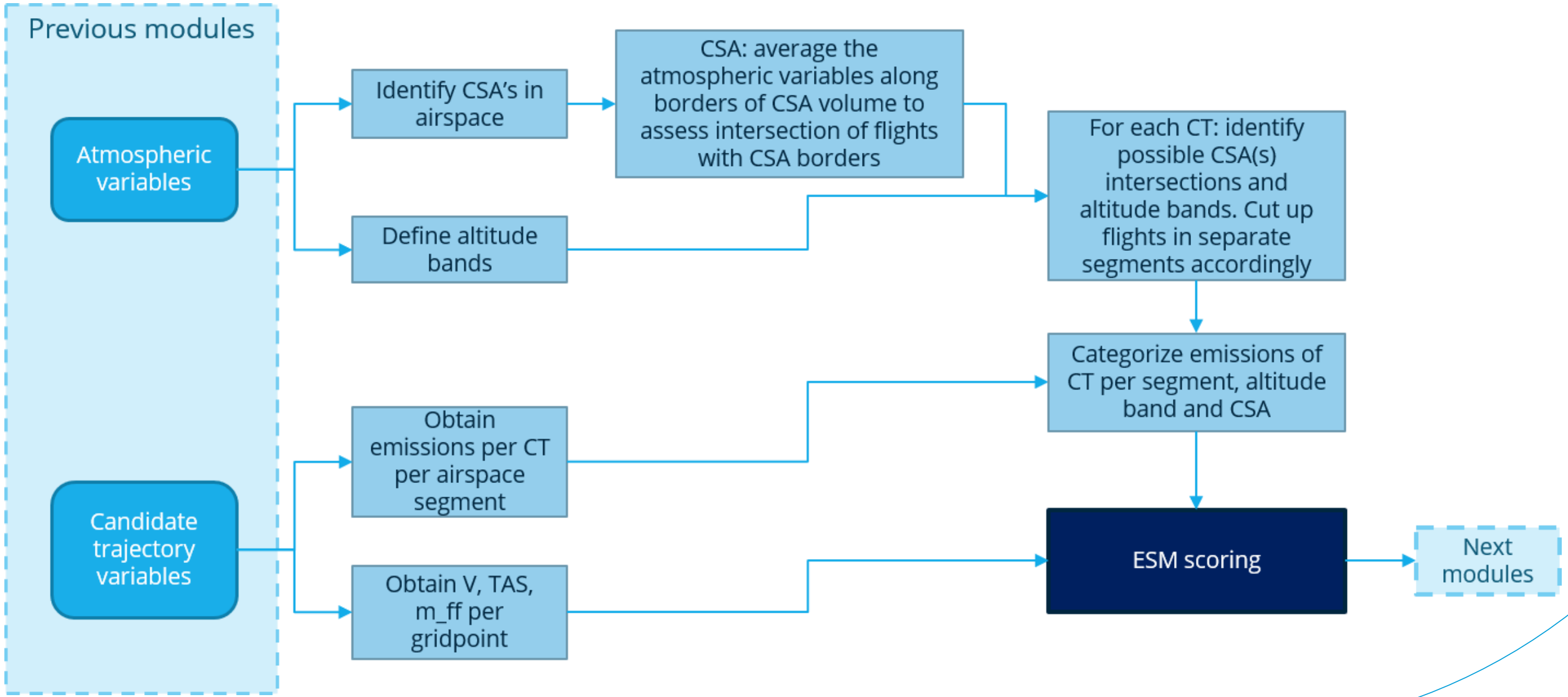
Solution concept

- **Non-CO_2 emissions** are dependent of location and time.
- **CO_2 emissions** are independent of location and time.

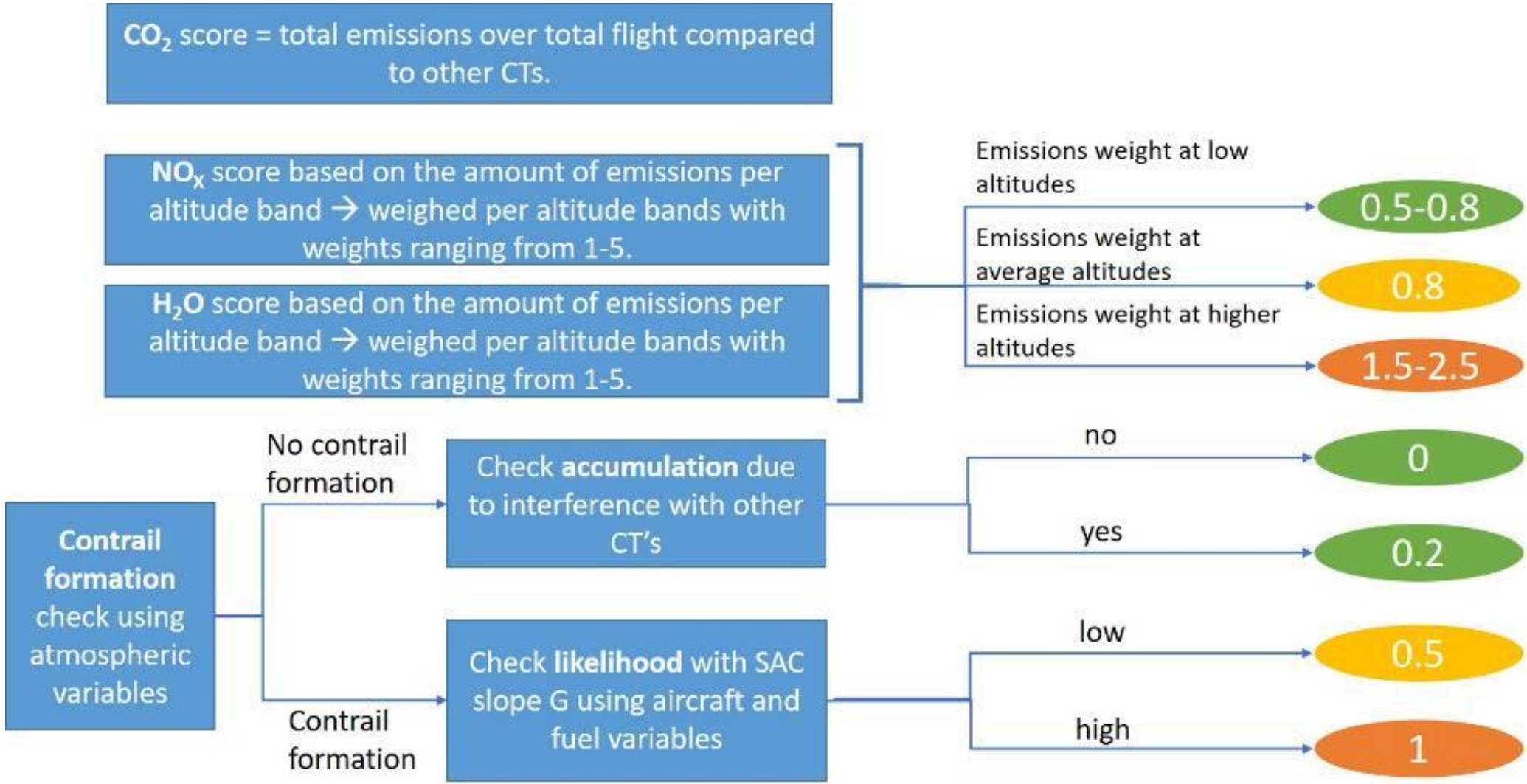
- The Environmental Scoring Module (ESM) assigns scores to each candidate trajectory (CT).
- ESM logic;
  - **CO_2** is linearly related to the total emitted amount per flight and therefore compared to other CTs
  - **NO_x and H_2O** emissions impact are related to altitude.
  - **Contrail formation** probability and impact are related to Climate Sensitive Areas (CSA)* and interference with other Candidate Trajectories.

*The current scope only considers Contrail Formation Region (CFR) to be relevant for the definition of CSAs

Solution schematic



ESM scoring elements

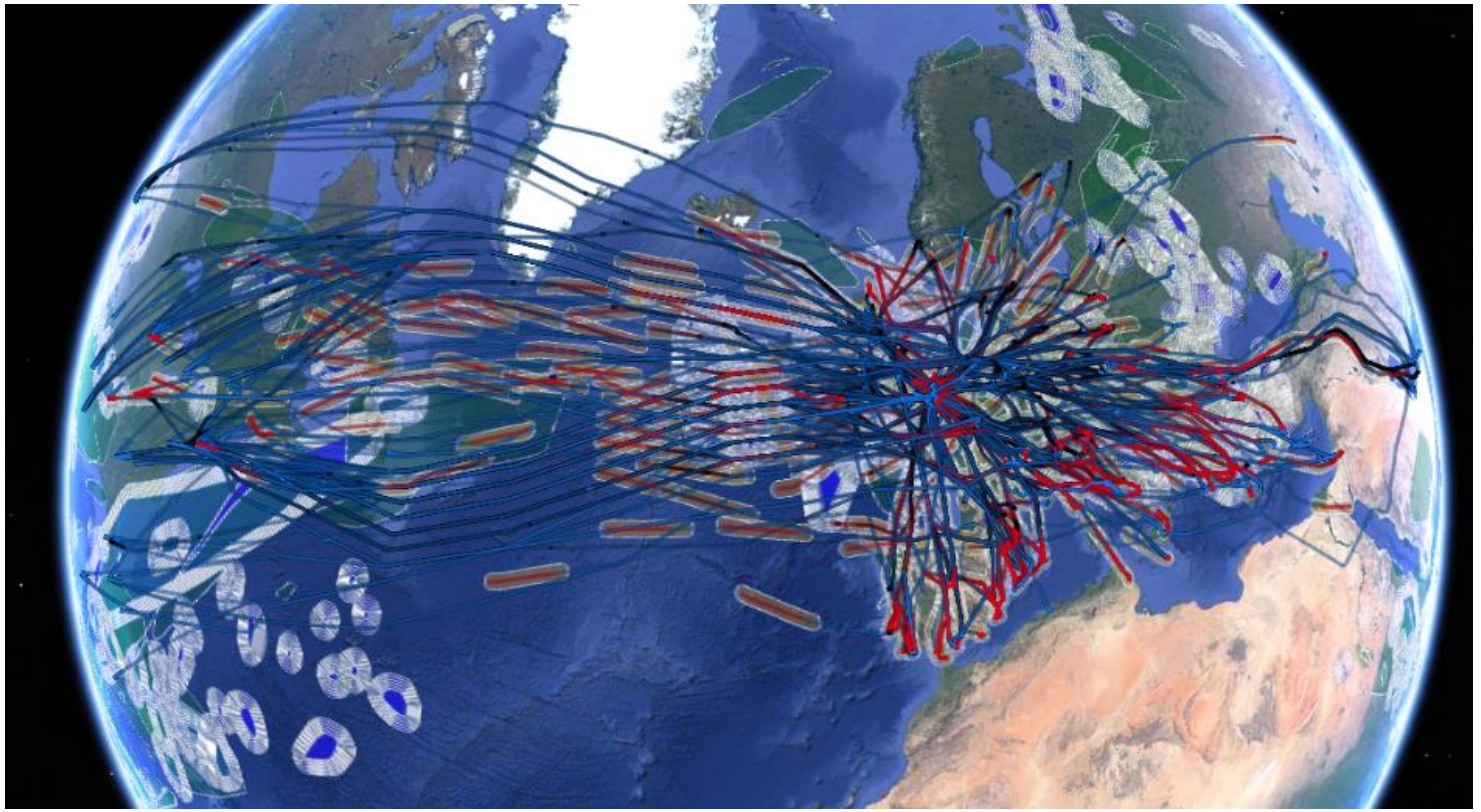


ESM scoring formula

- NO_x emissions are relatively small compared to CO_2 and H_2O emissions and in turn much larger than the contrail score that is expressed in a range from 0 to 1.
- For the purpose of comparing alternative candidate trajectories for a single flight, the scores are normalized to the reference flight, candidate 0 (c0).
- The ESM is designed to emphasize contrail formation in climate sensitive areas and dominates the score if the likelihood is larger than 50%.
- The overall ESM score is then defined as:

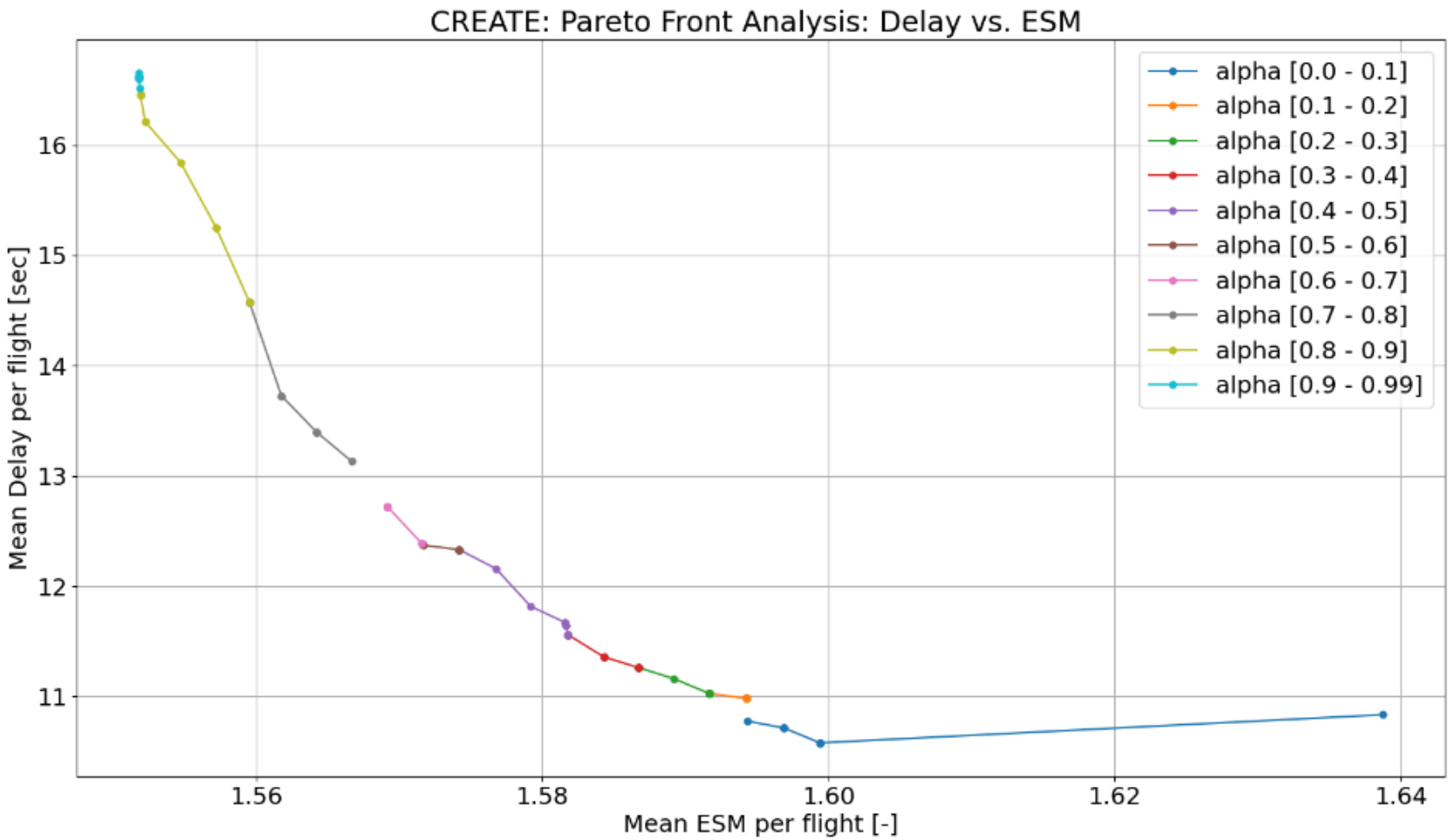
$$ESM = \frac{\left(\frac{CO2_{score}}{CO2_{score,c0}} + \frac{NOx_{score}}{NOx_{score,c0}} + \frac{H2O_{score}}{H2O_{score,c0}}\right)}{3} + 2 * Contrail\_score$$

Fast-Time Simulation exercise



- No-fly zones (thunderstorms) (blue), contrail zones (green) and all baseline flights (blue lines) with their related look-ahead time area (red lines)
- Simulation scenario based on historical flight tracks of 27 July 2018
- 1308 flights were applicable for the trajectory optimisation

Results



Higher *alphas*:

- Lower ESM score, leading to "greener" flights.
- Higher extra operating cost per flight.

Lower *alphas*:

- Lower extra operating cost, leading to cost-effective flights.
- Higher ESM score, leading to higher-environmental-impact solutions.

Concluding remarks and recommendations for future work

- CREATE-SOL-3 provides an initial KPI to provide a single metric taking into account both CO_2 and non-CO_2 effects of aircraft trajectories

- Improving the integration of computational modules is necessary to improve the overall computational time

- Improving the ESM scoring logic is required to make a “fair” balancing between the CO_2 and non-CO_2 effects

THANK YOU FOR YOUR ATTENTION

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