ISAE-SUPAERO research activities

Air transport sustainability and technology assessment

FAPESP Week France 2025

Thomas PLANÈS *(ISAE-SUPAERO)*

03/06/2025

AeroMAPS

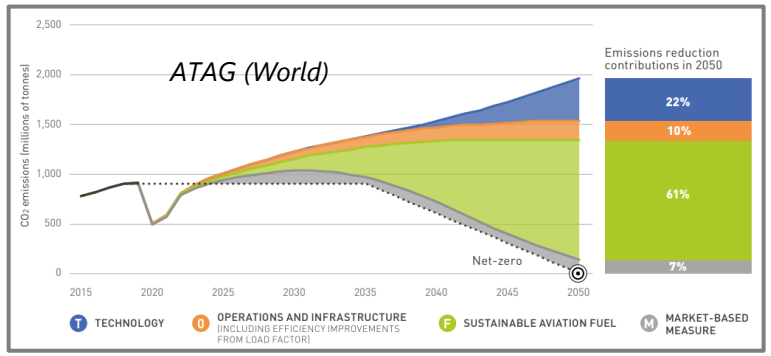
INSTITUTE FOR SUSTAINABLE AVIATION

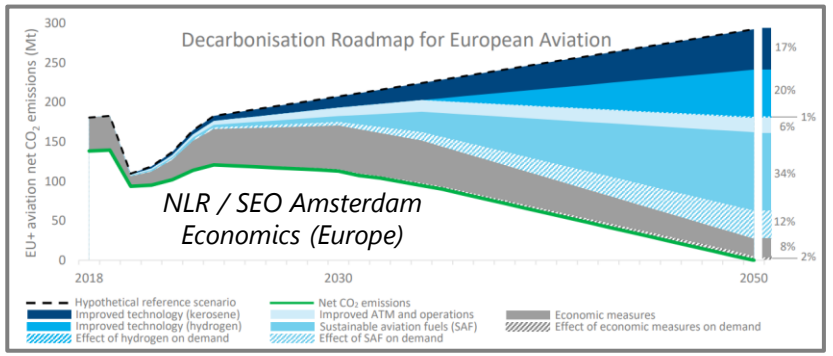
isae SUPAERO

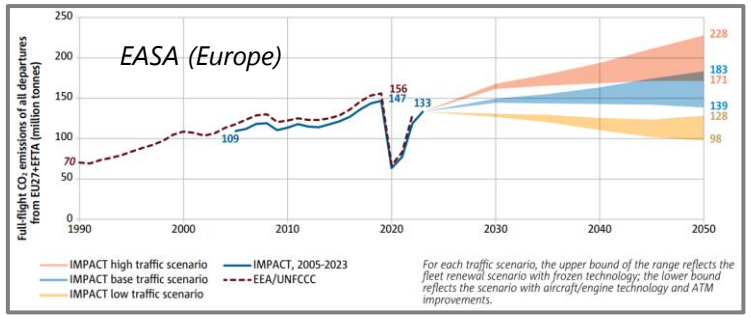
Modelling aviation transition scenarios

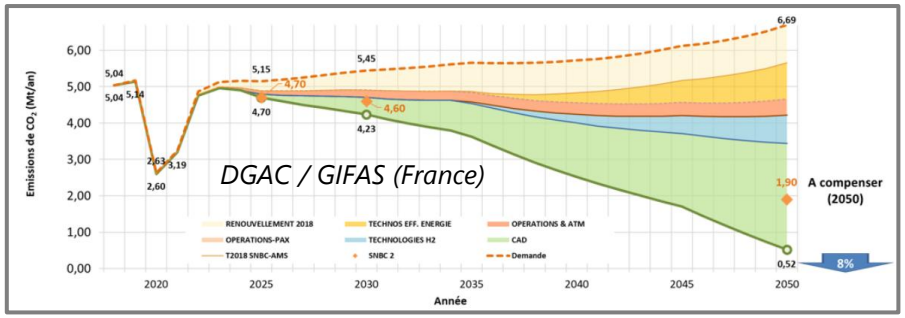
Numerous transition scenarios

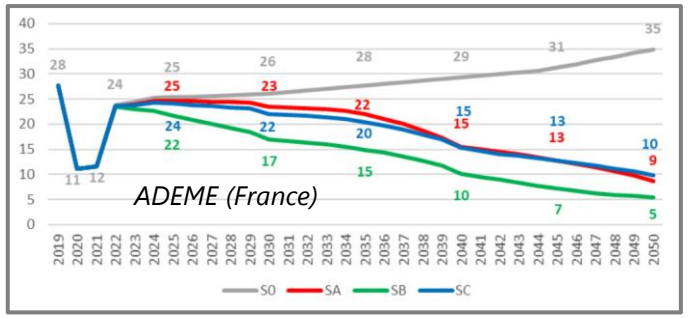
→ How can we reproduce them, model new ones, and deepen the analysis?

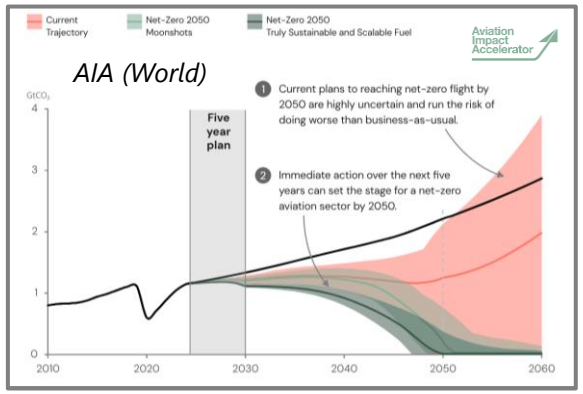


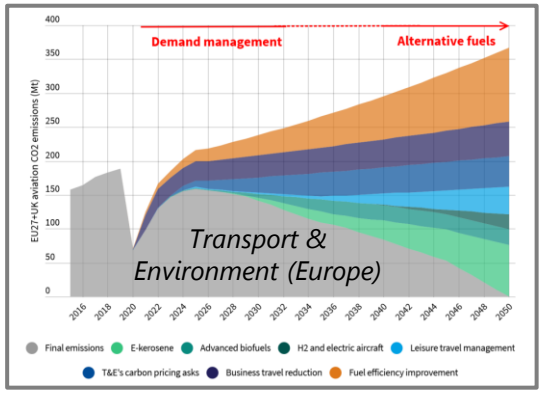


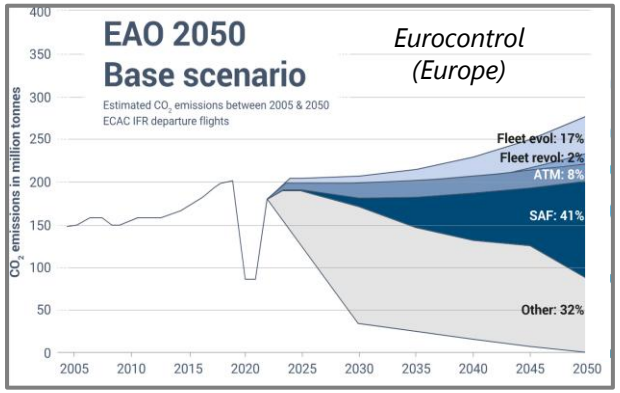


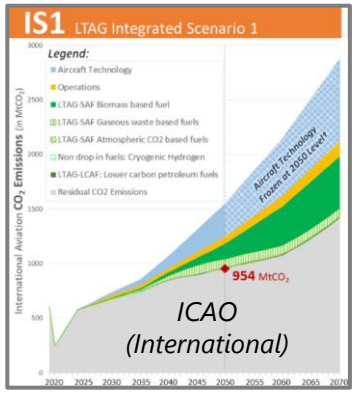












Research activities

ISAE-SUPAERO research on air transport sustainability and technology assessment

Transition modelling

Scenario simulation and assessment

AeroMAPS

Technology modelling

Aircraft and systems
Operations
Energy

Technology assessment

Fleet renewal
Technological scenarios
Emission inventories

Climate sciences

Climate modelling
Impact of climate change on aviation

Environmental sciences

Life cycle assessment
Planetary boundaries

Multidisciplinarity

Transition cost
Demand forecast
Air transport economy and sociology
Regulation and economic schemes

ISA INSTITUTE FOR SUSTAINABLE AVIATION

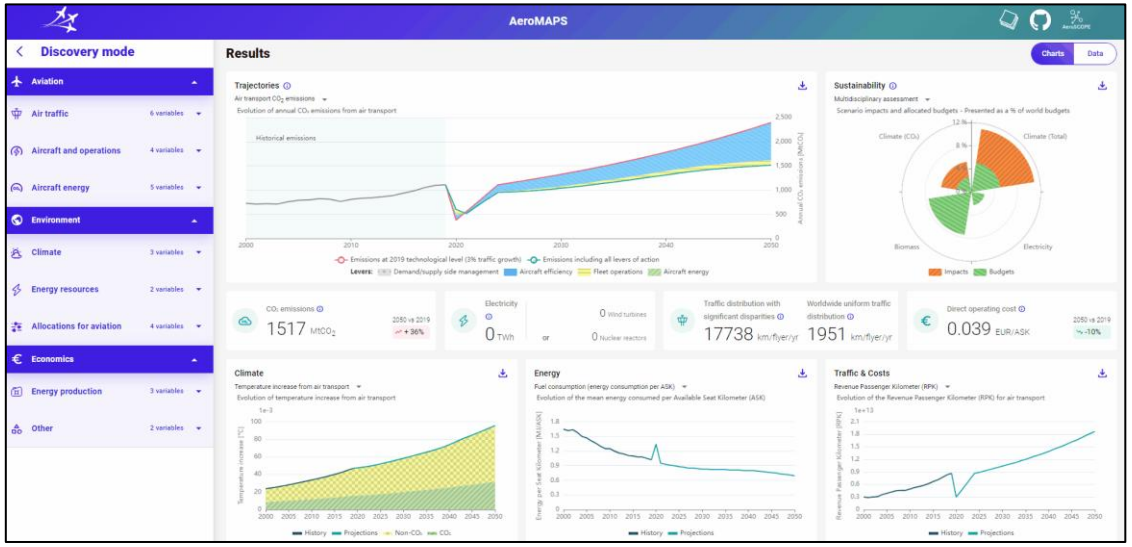
Transition modelling – Two tools

AeroMAPS

Objective: simulate air transport prospective scenarios
→ Build a sectoral integrated assessment model

Development of a **modular open-source framework** for performing multidisciplinary assessment of prospective scenarios

Insights: use of open-source Python frameworks (GEMSEO, lca-modeller…), dedicated user interfaces (Jupyter notebooks, GUI…)



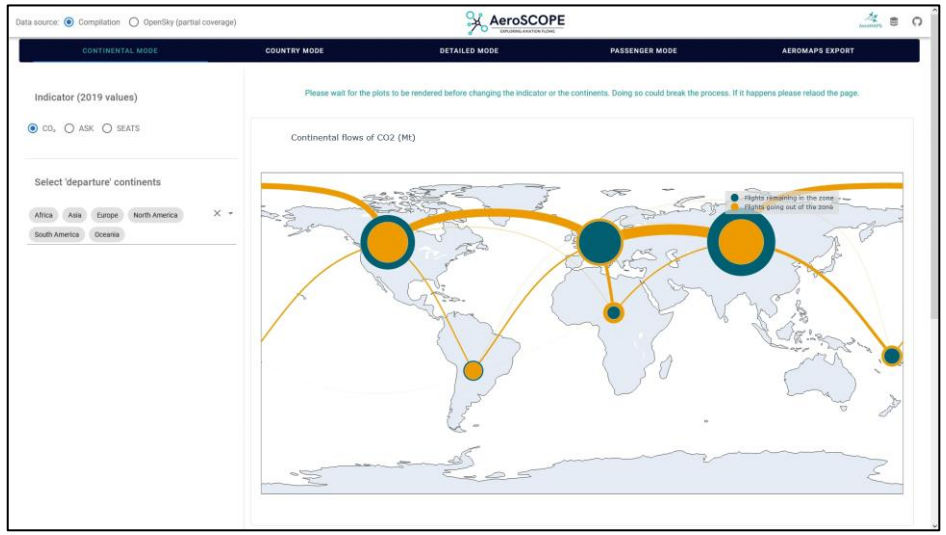
Planès, T., Delbecq, S., & Salgas, A. (2023). AeroMAPS: a framework for performing multidisciplinary assessment of prospective scenarios for air transport. Journal of Open Aviation Science.

AeroSCOPE

Objective: regionalising AeroMAPS

Compilation of an **open-source** traffic and emissions **dataset**

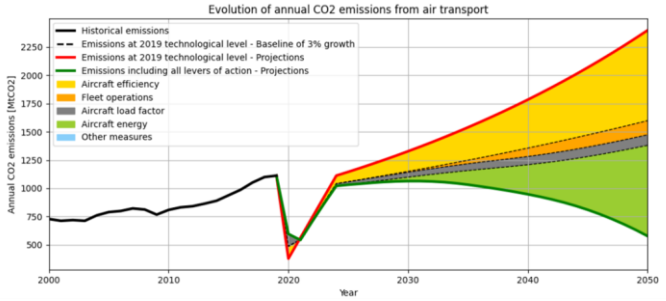
Development of a dedicated user interface for dataset exploration



Salgas, A., Sun, J., Delbecq, S., Planès, T., & Lafforgue, G. (2024). Compilation and Applications of an Open-Source Dataset on Global Air Traffic Flows and Carbon Emissions. Journal of Open Aviation Science.

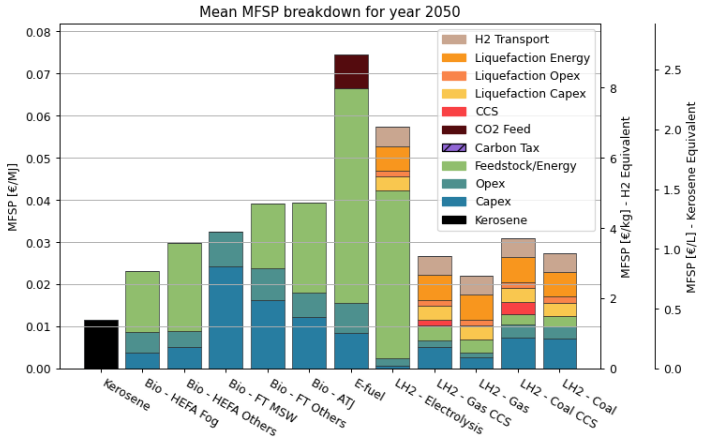
Transition modelling – A wide range of applications

Scenario simulations

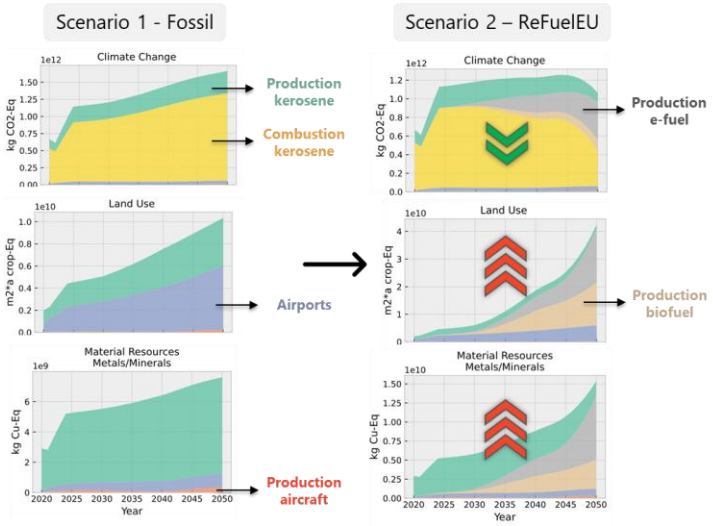


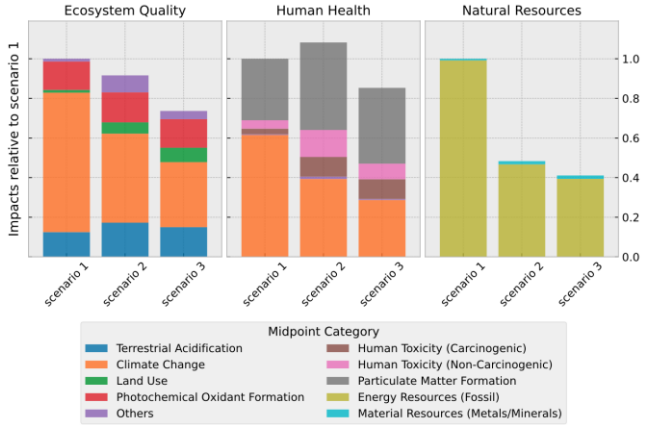
28 $GtCO_2$ 4600 TWh 10.3 EJ

Economic impacts

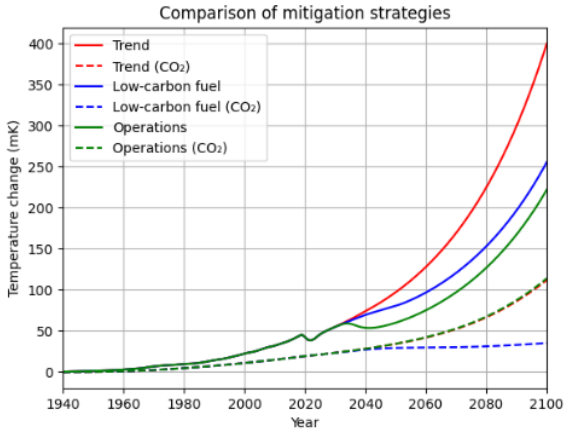


Environmental impacts



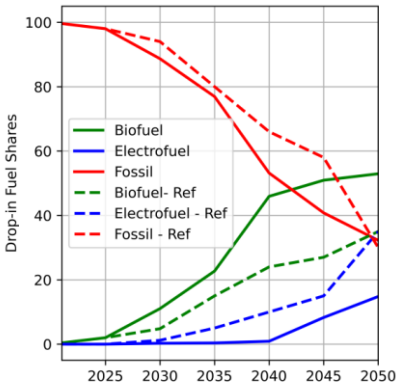


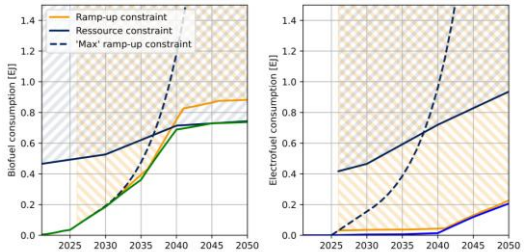
Climate impacts

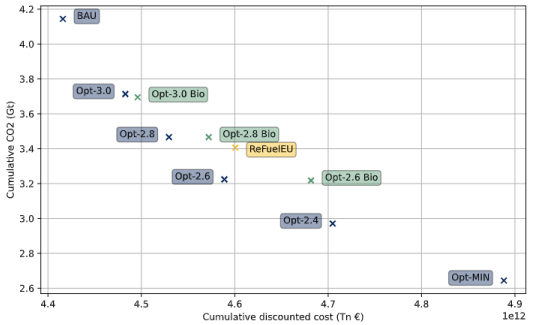


Optimisations

Techno-economic and environmental







Some examples

Climate sciences

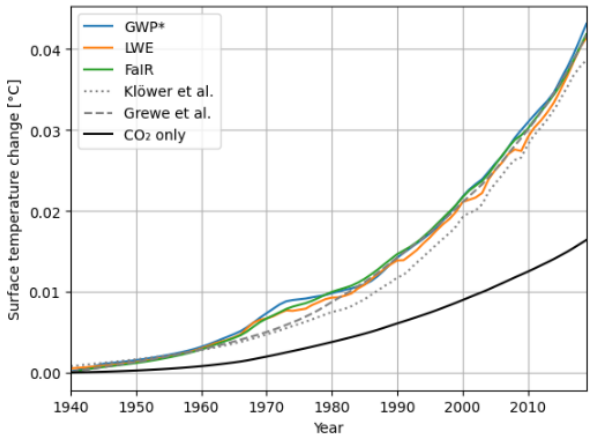
Methodology

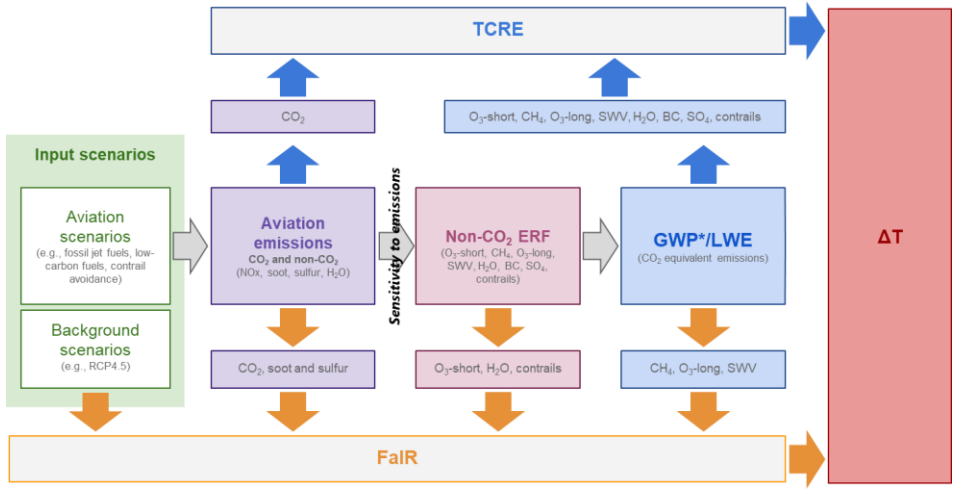
Development and modification of simplified climate models (dedicated metrics and emulators)

Validation and benchmarking

Model standardisation

Open-source release (AeroMetrics) and integration into AeroMAPS



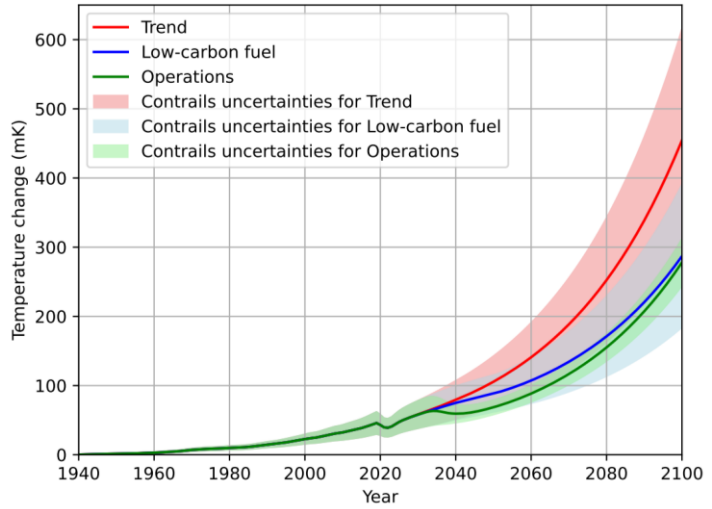


Applications

Comparison of mitigation strategies

→ Low-carbon fuels

→ Contrails avoidance

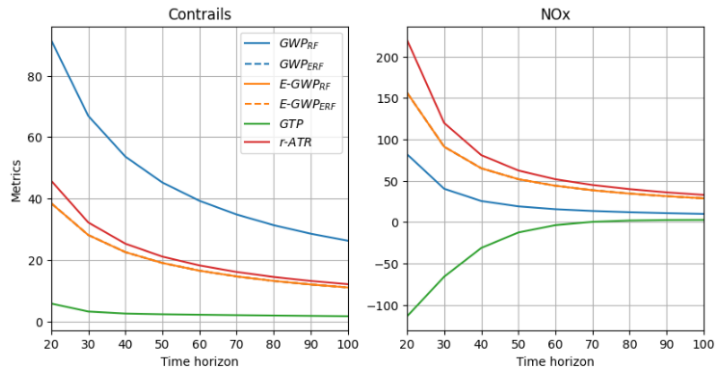


CO_2-equivalence metric calculation

→ Technology assessment

→ Life cycle assessment

→ Pricing



References: Planès et al. (2021), Arriolabengoa et al. (2024)

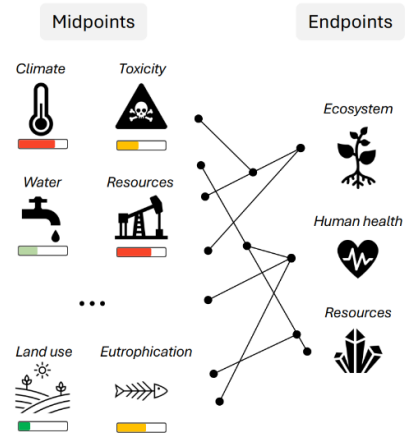
Environmental sciences

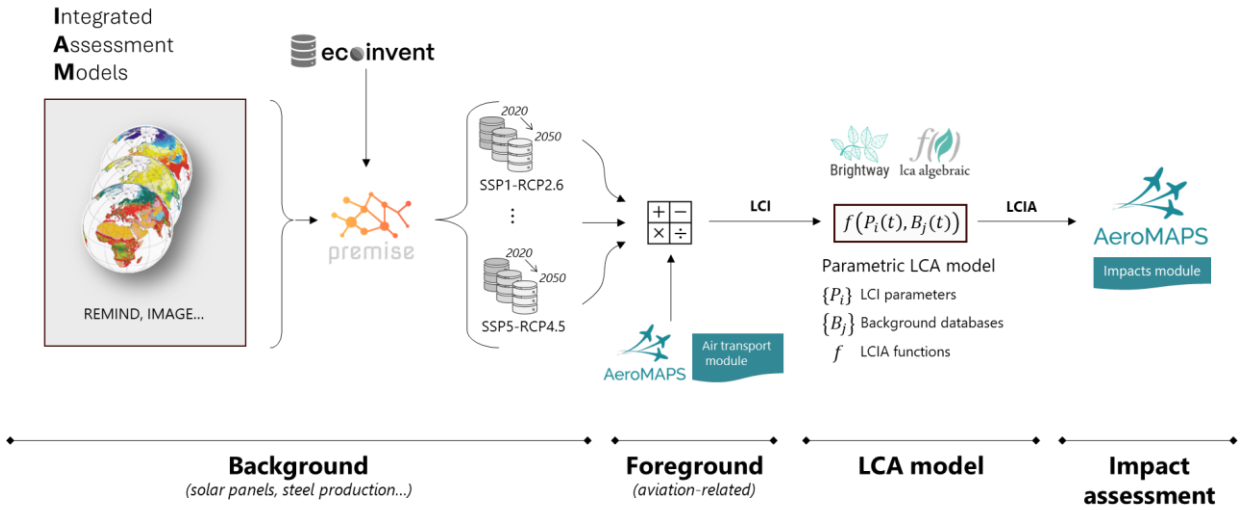
Methodology

Development of a prospective life cycle assessment method

Dedicated framework (lca-modeller)

Generic (AeroMAPS, FAST-OAD)



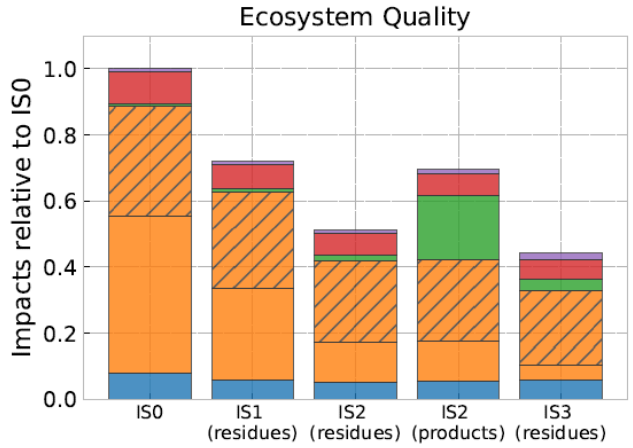


Applications

Comparison of mitigation strategies

→ Biomass feedstock

→ Electricity source

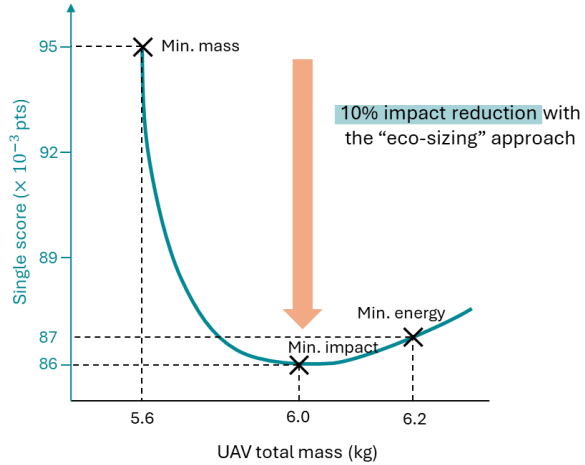


Overall aircraft design

→ Optimisation (UAV)

→ Hybridisation (CS-23)

→ Missions and fuels (CS-25)



References: Pollet et al. (2024), Planès et al. (2025), Pollet et al. (2025)

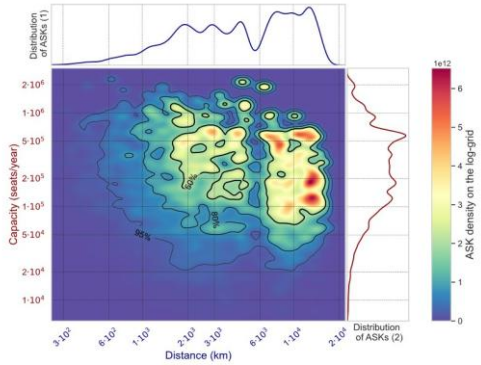
Technology modelling and assessment

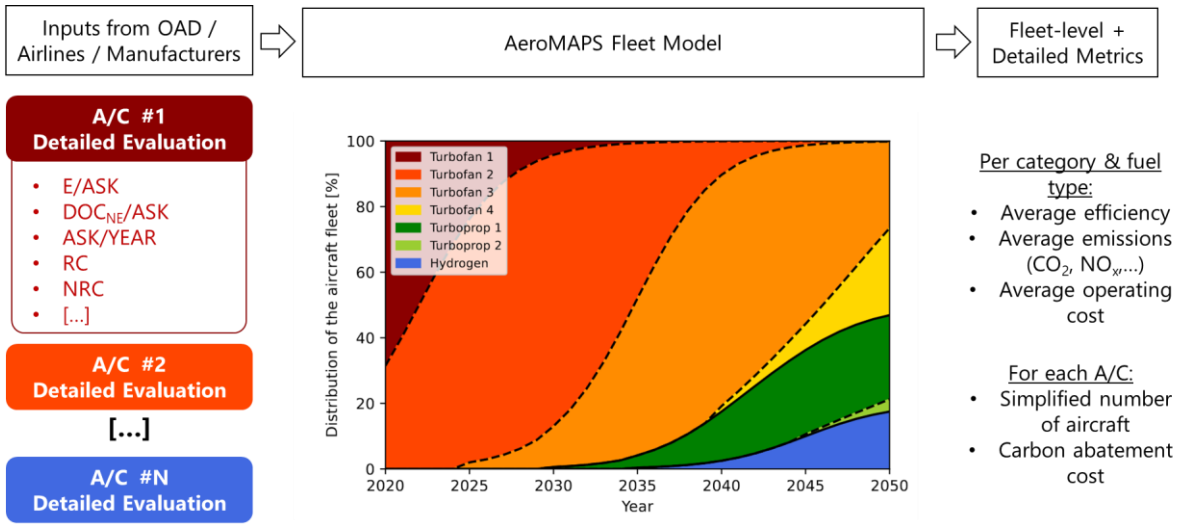
Methodology

Several approaches for modelling fleet efficiency

- Mean annual efficiency gains
- Fleet renewal models with logistic functions
- Data-driven comprehensive fleet renewal models (production, retirement, aircraft-route allocation, productivity)

→ Technology assessment





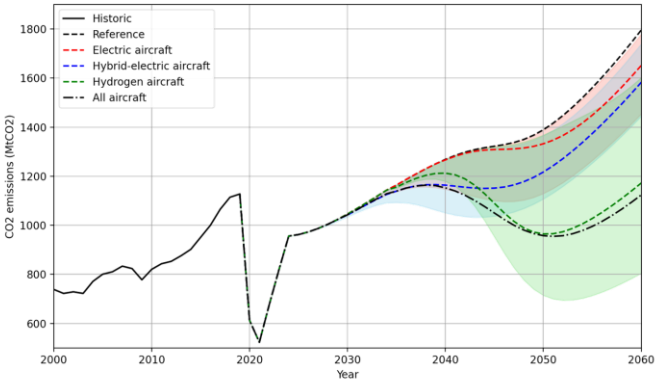
Per category & fuel type:
- Average efficiency
- Average emissions (CO_2, NO_x...)
- Average operating cost

For each A/C:
- Simplified number of aircraft
- Carbon abatement cost

Applications

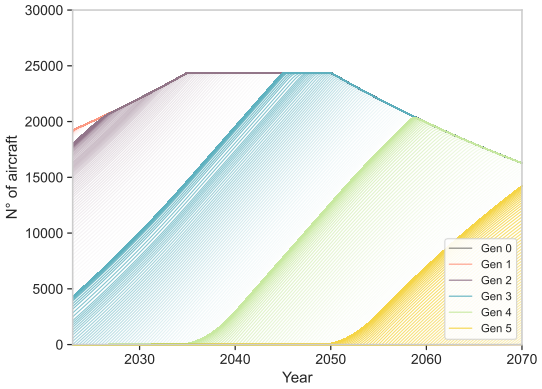
Technology comparison

→ Electric aircraft
→ Hybrid-electric aircraft
→ Hydrogen aircraft



Fleet renewal strategies

→ Illustrative scenario for the aircraft demand
→ Optimised deliveries and retirements

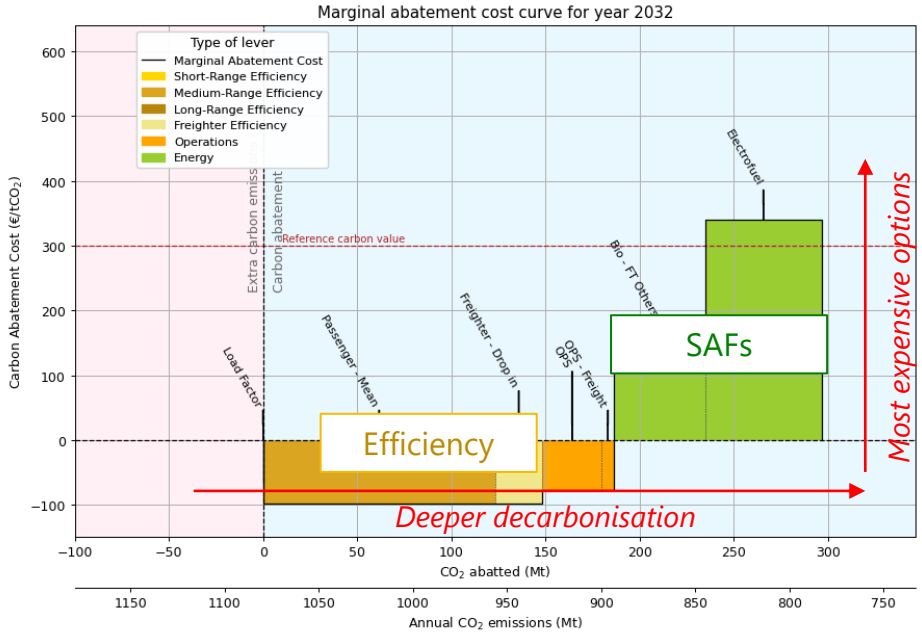


References: Delbecq et al. (2022), Planès et al. (2023), Delbecq et al. (2023), Delbecq et al. (2024), Viry et al. (2024) Viry et al. (2025)

Multidisciplinarity

Abatement costs

Simple method to evaluate individual projects

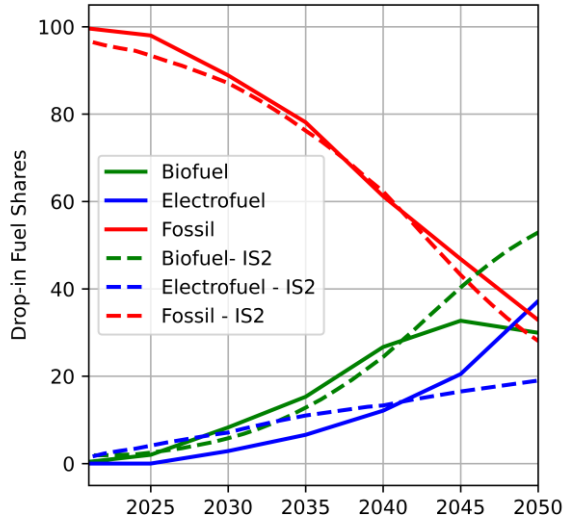


Abatements Costs ≈ Cost per CO_2 avoided

- Compare projects
- Align aviation scenarios with societal carbon values and level of ambition

Direct optimisation

Rigorous cost-efficient scenario design



IS2 consumes 26% of biomass in IEA NZE scenario

Cost-optimisation of blending mandates by constraining biomass availability (same carbon budget, ramp-up/down constraints)

References: Salgas et al. (2025), Planès et al. (2025), Salgas (2025)

Roadmap

Current and future research works

- **Climate and environmental sciences**
  - Climate models and metrics (benchmarking)
  - LCI (fuels), LCIA (update for climate and others)
  - Planetary boundaries and downscaling

- **Technology modelling and assessment**
  - Aircraft design
  - Fleet renewal: production, retirement, productivity, aircraft/route allocations
  - Overview of operations efficiency
  - Contrail avoidance and SAF effects

- **Multidisciplinarity**
  - Development of new models at global and route levels based on socio-economic data
  - Sufficiency measures (e.g. quotas integrating sociological analyses)
  - Market equilibrium and sociological indicators
  - Scheme modelling: CORSIA, EU-ETS

- **Transition modelling and framework features**
  - Representative scenarios
  - Genericity, coupling, optimisation, uncertainties
  - Interactions between regions and stakeholders

DTU AIRBUS INSA TOULOUSE

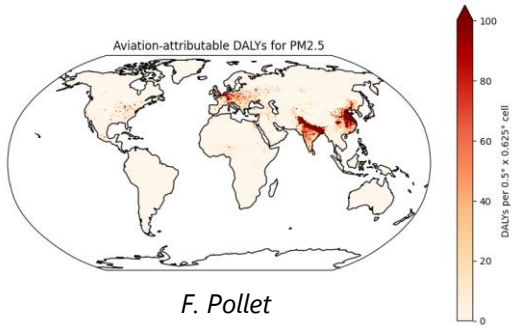
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TU Delft

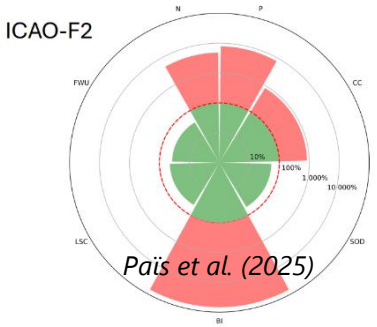
Université de Lille

tbs Business School

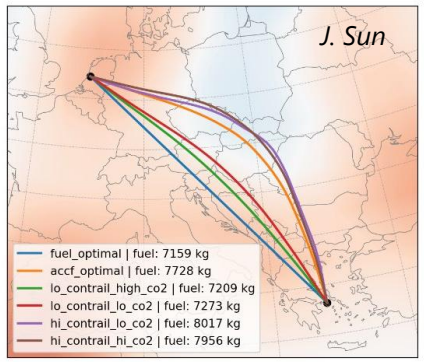
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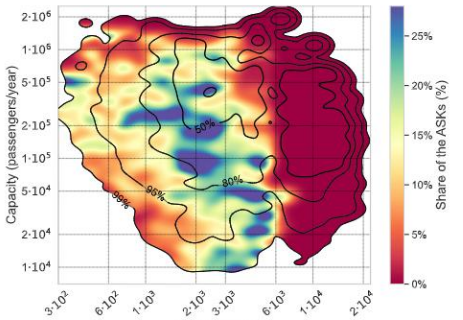


F. Pollet

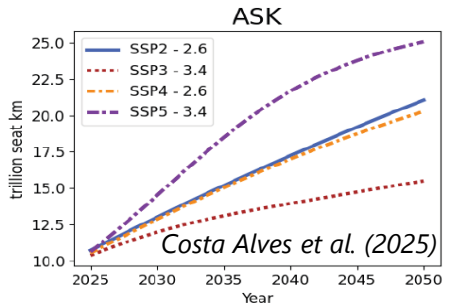


Païs et al. (2025)

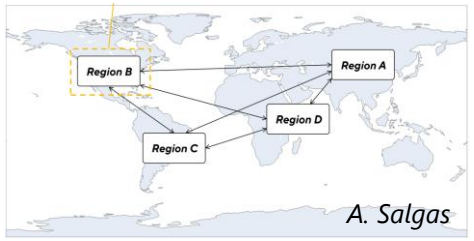




Viry et al. (2025)



Costa Alves et al. (2025)



A. Salgas