#ArchitectingAviation

GLOBAL IMPACT ASSESSMENT: WORKFLOW & UNCERTAINTY QUANTIFICATION

Automated multi-disciplinary analysis for impact assessment and uncertainty quantification in future aviation development.

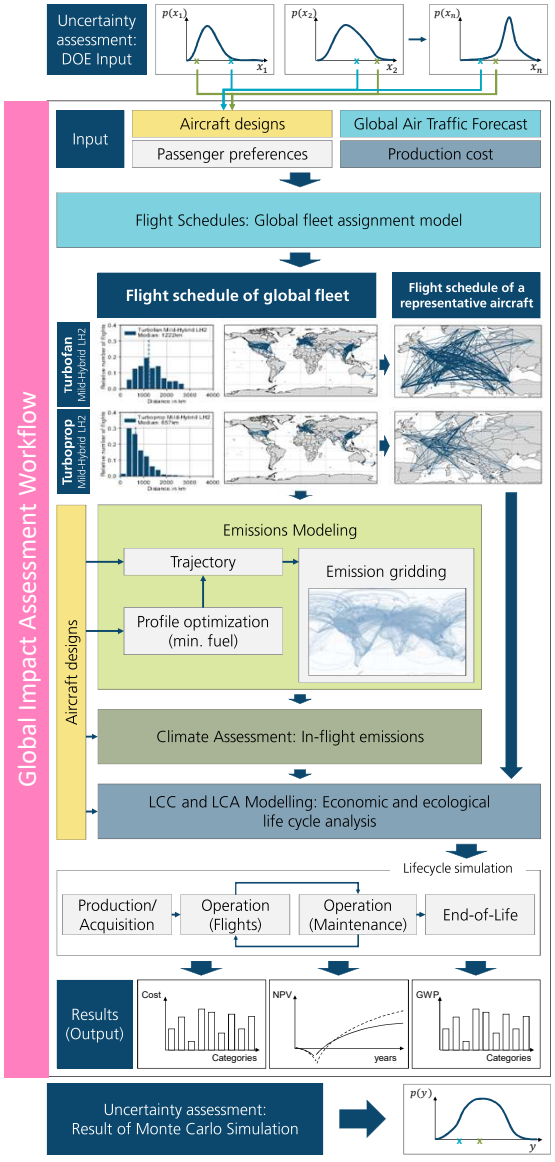

Figure 1: Global impact assessment workflow including uncertainty studies

Integrated Framework for Global Aviation Impact Assessment and Uncertainty Quantification

Global impact assessment requires an integrated approach, combining fleet forecasting, emissions modeling, climate impact analysis, and economic and ecological life cycle analysis. To streamline this process, an automated workflow within the Remote Component Environment (RCE) enables seamless data exchange and large-scale studies, incorporating Design of Experiments (DOE) for uncertainty quantification (see Figure 2).

This framework improves the accuracy and efficiency of aviation impact studies, supporting data-driven decision-making for sustainable aviation development.

Global Air Traffic Forecast (FORMO/Scheduler)

FORMO estimates future traffic demand on route level and on global scale up to 2070 (constrained / unconstrained). It processes fleet development, retirement, utilization, and load factors for reference and concept aircraft. The Scheduler assigns the future fleet to routes without economic optimization.

Flight Scheduling (FoAM-Dynamic)

FoAM-Dynamic performs a global fleet assignment, considering the global air traffic forecast, fleet development, and factors such as aircraft operating characteristics, energy carrier prices, and passenger preferences. The model can generate either a global flight schedule (for GRIDLAB) or an aircraft-specific flight schedule (for LYFE) (see Figure 1).

Emission Modeling (GRIDLAB)

GRIDLAB processes individual aircraft trajectories to generate a comprehensive 3D global emissions inventory. Using projected flight schedules from the fleet model (FoAM-Dynamic), it calculates emissions at all time steps, ensuring a high-resolution representation of aviation emissions over time for environmental impact assessments (Figure 1).

Climate Assessment (AirClim)

AirClim evaluates the climate impact on GRIDLABs calculated aviation emissions over time. By analyzing emissions inventory data, it quantifies long-term climate effects, supporting sustainable policy and technology development (Figure 1).

LCC and LCA Modeling (LYFE)

LYFE performs economic and ecological life cycle analysis based on flight schedules (FoAM-Dynamic) through modular, discrete-event simulations. Each life cycle phase is analyzed based on attributes like duration, cost, revenue, and environmental impact, producing key metrics such as total cost, Net Present Value (NPV), and Global Warming Potential (GWP) for the whole life cycle (Figure 1).

Uncertainty Studies

Uncertainty quantification is performed through DOEs combined with Monte Carlo simulations, enabling a systematic exploration of input variability across the integrated assessment workflow. By evaluating multiple scenarios, DOE enables the identification of key sensitivities and their impact on results.

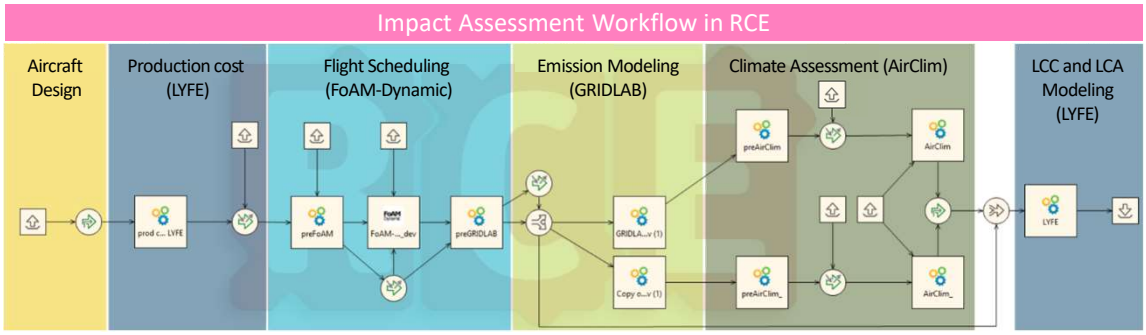

Figure 2: Impact Assessment Workflow modeled in the Remote Component Environment (RCE)

ABBREVIATIONS:

- RCE: Remote Component Environment
- DOE: Design of Experiment
- LCC: Life cycle costing
- LCA: Life cycle assessment
- NPV: Net Present Value
- GWP: Global Warming Potential

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