



Success story

Optimizing commercial aircraft designs to use future aviation fuels

Pieter-Jan Proesmans, PhD Candidate in the Flight Performance & Propulsion group at Delft University of Technology, used modeFRONTIER to perform multi-objective aircraft design optimization to compare future aviation fuels.

Challenge



The modeFRONTIER post-processing tools for DOE or optimization results allow aircraft design researchers to verify the design solutions and trends quickly.

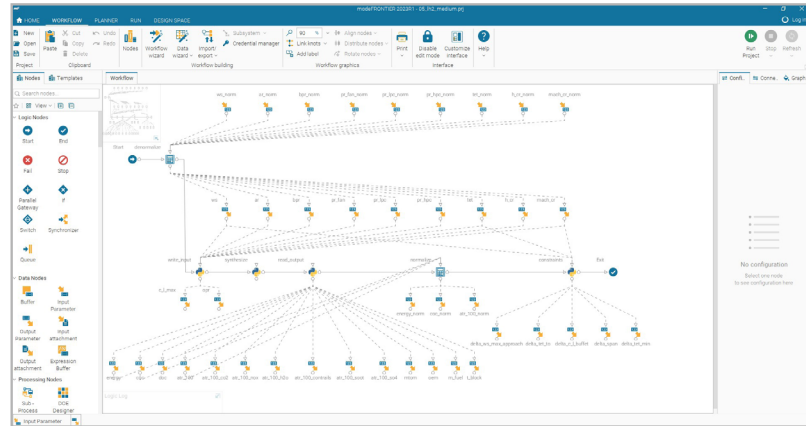
This research¹ has been undertaken in the framework of the GLOWOPT project sponsored by the EU's Clean Sky 2 program, and under the supervision of Dr.ir. Roelof Vos, associate professor at Delft University of Technology. The objective is the development and validation of Climate Functions for Aircraft Design (CFAD) with respect to minimizing global warming and their application to the Multidisciplinary Design Optimization (MDO) of next-generation aircraft for relevant market segments.

To reach this goal, novel fuels, such as liquid hydrogen (LH2) and sustainable aviation fuel (SAF) can provide more sustainable solutions. However, the climate objective conflicts with the typical design objective of minimal operating costs. While these two fuels can offer a significant reduction in climate impact, they are also more expensive and have consequences for the aircraft design (in the case of cryogenic LH2 tanks).

1. Proesmans, P., & Vos, R. (2022). Comparison of Future Aviation Fuels to Minimize the Climate Impact of Commercial Aircraft. In AIAA AVIATION 2022 Forum: June 27-July 1, 2022, Chicago, IL & Virtual [AIAA 2022-3288] (AIAA AVIATION 2022 Forum). American Institute of Aeronautics and Astronautics Inc. (AIAA). <https://doi.org/10.2514/6.2022-3288>

Solution

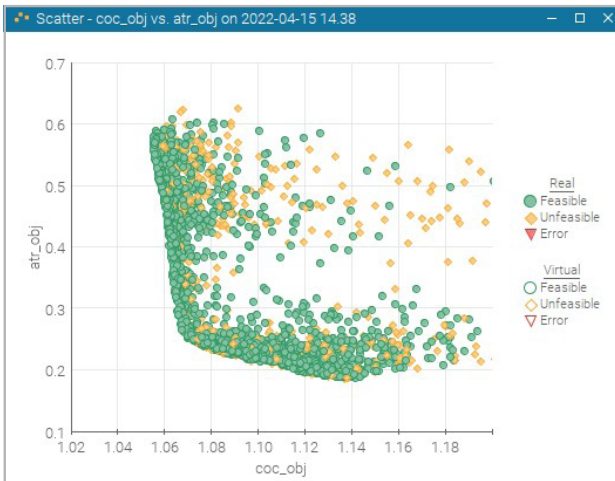
The modeFRONTIER Multidisciplinary Design Optimization (MDO) framework was selected to investigate the climate impact reduction and operating costs for hydrogen and SAF fuel in regional, medium-range and long-range aircraft categories. The cost-optimal, kerosene-powered aircraft served as the reference case for all multidisciplinary aircraft design optimizations. The MDO process was set-up in a modeFRONTIER workflow. Its Python interface made it possible to orchestrate in-house tools for aerodynamics, propulsion, mission analysis, mass estimation and climate impact. Next, the optimization strategy was executed. The piLOPT algorithm evaluated thousands of configurations by changing airframe, turbofan engine and mission design variables to obtain the cost versus climate trade-off for all fuel types in the three aircraft categories.



modeFRONTIER multidisciplinary workflow used for aircraft design optimization to compare future aviation fuels

Benefits

“The easy-to-use parallel coordinates and scatter matrix charts were very helpful in gaining conceptual insights. One of the key findings was that the SAF-powered aircraft are preferred over the cost-optimal hydrogen aircraft for the regional and medium-range categories. With modeFRONTIER, we could perform the multi-objective optimization and post-processing in a much faster and user-friendly way compared to when we had to rely on programming libraries. In the future, we will investigate how to combine the aircraft optimization with a network allocation routine to update not only aircraft design variables, but also top-level aircraft requirements” said Pieter-Jan Proesmans, PhD Candidate in the Flight Performance & Propulsion group at Delft University of Technology.



Pareto-optimal solutions for medium-range aircraft



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