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Title

Scalability assessment of hybrid-electric technology application to various aircraft classes – an overview of opportunities and challenges

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Abstract

Over the past decade, many research initiatives have investigated various applications of aircraft electrification and hydrogen technology, often in combination with some form of distributed (electric) propulsion around the airframe. Typically these initiatives address only a single vehicle or class of vehicle [1-10]. However, the application of novel propulsion systems or energy carriers is expected to differ across vehicle classes or even scale across classes when these technologies evolve over time. The objective of the EU-funded research project CHYLA (Credible HYbrid eLectric Aircraft) was to identify areas suitable for scaling, as well as opportunities or limitations/challenges for the applications of key radical technologies over different aircraft classes, where the credibility of underlying technology assumptions is modeled as an explicit factor. The latter is achieved in a multidisciplinary design optimization (MDO) framework.

To develop such a "landscape" of opportunities and challenges for technology applications, a framework was developed combining an energy network model [11] with a conceptual aircraft design framework performing the initial aircraft design [12] and sensitivity studies [13], and credibility-based MDO [14]. For the latter MDO studies, designs for various aircraft categories are optimized, taking the credibility of reaching a certain technology level explicitly into account (e.g., the confidence of reaching a certain battery performance). Additionally, aircraft design was directly coupled to airline network optimization to assess operations and economics of such designs [15], aimed at minimizing climate impact.

This article will present the activities performed over the final trimester of the project (October 2022 - May 2023), where the particular focus is on assessing the scalability of different technology applications and maximizing the credibility of designs. Therefore, this paper will present the final outcomes of the project, presenting a "landscape" of opportunities and challenges for different technology applications with a particular focus on the commuter and regional aircraft, including their use in a regional airline network, the cross-over points between CS-23 and CS-25 regulations and cross-over points of technology application at airport gate limits (particular type C gate span constraints). Where applicable, differences in scalability or technology application to even larger or smaller classes of aircraft will be made.

Hybrid and electric aircraft design is very sensitive to the selection of power control parameters, in this project, shaft power ratio, supplied power ratio, and throttle setting, to achieve the lowest possible energy/fuel consumption. From an operational point of view, the off-design performance is important, yet this is also significantly impacted by these power control parameters. Therefore, this article will also provide insight into how to operate such aircraft.

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