Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: HEPAEM / SUSTAV
Corresponding author: Balack Philip
e-mail of corresponding author: philip.balack@dlr.de
Type: Oral
Status of corresponding author: Regular

Title
Architectural Trade-offs for a Hybrid-Electric Regional Aircraft

Authors
Philip Balack [1], Georgi Atanasov [2], Thomas Zill[3]*

** Corresponding author*
[1] German Aerospace Center (DLR), 21129 HAMBURG, Germany, philip.balack@dlr.de
[2] German Aerospace Center (DLR), 21129 HAMBURG, Germany, georgi.atanasov@dlr.de
[3] German Aerospace Center (DLR), 21129 HAMBURG, Germany, thomas.zill@dlr.de

Abstract
Research entities and the aviation industry are collaborating to reduce the greenhouse gas emissions of the global aircraft fleet. To move away from fossil fuels as energy carriers while reducing the aircraft´s primary energy demand are the ideal but challenging means to achieving this target. The research activities within the German government funded project TELEM have shown on a conceptual level that both measures could be realized for regional aircraft with an optimized hybrid-electric propulsion architecture. Short, but very frequently flown distances up to 200nm and more could be served fully electrically by advanced propeller-driven aircraft with an assumed entry-into-service in 2035.

A synergistic aircraft integration strategy is the key requirement for novel hybrid-electric propulsion systems to be a viable option for future products. This paper gives an overview of integration concepts pursued in the project and reflects on various design aspects of hybrid-electric aircraft. Two design decisions stand out to promise a double-digit energy saving potential compared to an improved conventional turboprop technology: First, a serial-hybrid electric architecture was selected as it enables distributed electric propulsion and increases the integration flexibility of the power providers[1]. The second decision concerns the hybridization strategy between electrical and fuel-based power providers. Many hybrid-electric studies focus on complex control strategies, i.e. optimum power splits since the battery-bound energy is found not to be able to provide sufficient range by itself due to their comparably low specific gravimetric energy. Nevertheless, in this paper's hybridization concept, fully-electric and therefore emission-free operation is enabled by expanding the range and operations via a separate fuel-based range extender that can be turned on and off during flight. The range extender´s further major advantage is that it provides the fuel-based, "low-weight" energy required for the reserve mission, therefore freeing up energy stored in the heavy batteries for regular operation.

The aircraft´s propulsion architecture is optimized with regard to the number of propellers as to yield the best efficiency and to enable commonality with smaller aircraft leading to potential cost reductions among aircraft classes. Furthermore, the optimal number of range extenders and their installation options are discussed and evaluated. While the battery is fitted to satisfy all typical power requirements, its size is a design variable allowing for either lower total weight or higher range. The impact of the battery size is analyzed with respect to aircraft total mass, energy consumption and turnaround time. The optimal wing integration i.e. high- or low-wing configuration is quantified via an empirical weight estimation and engineering judgement. Finally, a cooling concept, which is essential for the hybrid-electric propulsion architecture and its requirements are discussed and a favorable option selected.

References

[1] Biser S. et.al., "Design Space Exploration Study and Optimization of a Turbo-Electric Propulsion System for a Regional Aircraft", *AIAA Propulsion and Energy 2020 Forum*, Virtual Event, American Institute of Aeronautics and Astronautics