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Conceptual studies of hybrid-electric passenger airplanes

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Abstract

The present paper illustrates the work performed within the EU-funded H2020 MAHEPA project in studying the scalability of hybrid-electric (HE) propulsion technologies for regional aviation applications. The MAHEPA project addresses serial multiple HE power-train architectures in which the battery pack is complemented by a power generation system (PGS). Two PGS variants are investigated: the first uses a thermal engine coupled with an electric generator and the second employs a hydrogen-fed fuel-cell system. The latter is further considered in two versions: the first employing gaseous hydrogen storage (GH2) on board and the second liquid storage (LH2). The implications of these alternatives play a crucial role in the design of the aircraft.

We discuss the preliminary sizing of two classes of passenger airplanes, ranging from CS-23 commuters to CS-25 large regional liners, making use of an aircraft design methodology specifically developed for HE solutions. This includes the detailed modelling of the battery pack, the fuel cell system and the hydrogen tank, for both the GH2 and LH2 cases, which imply a high-pressure vessel and a cryogenic tank, respectively. For both certification categories, a preliminary validation with respect to existing production aircraft and existing pure-electric and HE experimental models confirms the reliability of the HYPERION preliminary tool. This has been applied to the conceptual study of 19-passenger and 70-passenger clean-sheet design solutions based on specified mission requirements. In the present discussion, “concentrated” propulsion (i.e. twin wing-mounted thrust-generating units) was considered, leaving more advanced configuration options for further discussion. A parametric analysis was carried out to assess the impact of expected technology maturation in the time horizon ranging from 2025 to 2050, showing promising opportunities for enhanced mobility and transportation network sustainability.

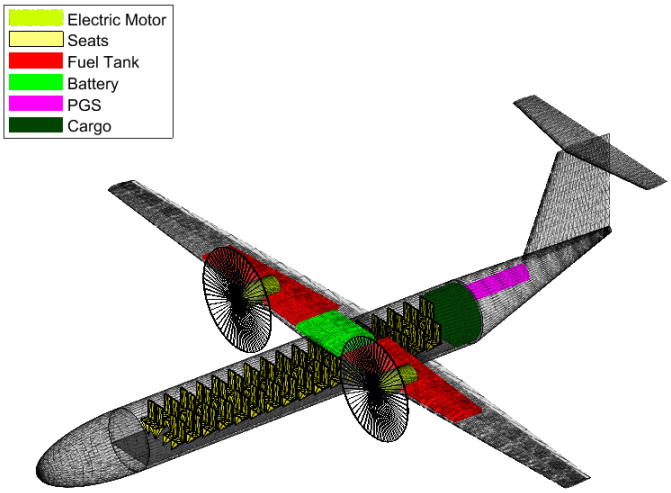

Figure 1: A thermal serial hybrid-electric sizing solution for a 70-passenger aircraft.

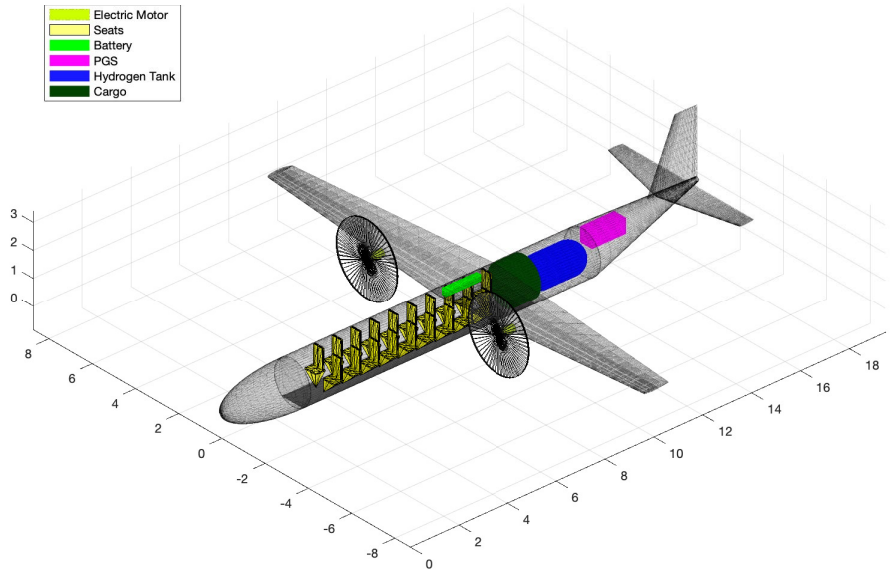

Figure 2: A liquid-hydrogen serial hybrid-electric sizing solution for a 19-passenger aircraft.