The use of Finite Element Method and semi-empirical equations for weight estimation of the passenger aircraft utilizing innovative technological solutions

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The progressing climate changes and the complicated economic situation in the world require steps to be taken to reduce both the emission of harmful gases and the costs generated by the air traffic. Groups of engineers and scientists are working on solutions aiming to reduce, among others, fuel consumption in passenger aircraft, which leads to achieving the goals set by organizations such as European Commission (Flightpath 2050) or ACARE (SRIA) in their guidelines for the aviation industry. One of such innovative solutions is fuselage wake-filling propulsion studied in the CENTRELINE project. The scope of the project included tasks leading to estimate the increase in the weight of the aircraft structure caused by the use of additional propulsion and equipment needed for its operation. For this purpose, the concept of both the structural connection of the propulsor with the aft-fuselage and the empennage was prepared, as well as the concept of a hybrid fuselage structure based on the combination of a classic layout with a geodetic layout. An iterative design process was carried out, supported by FEM analysis, aimed to propose a structure, that meets the requirements of CS-25 regulations, with the best possible strength and stiffness to weight ratio. As it was not possible at this stage of the project to estimate the weight from, for example, a complete CAD model, it was necessary to develop a method that produces the most reliable results possible while taking into account the limitations of the early Technology Readiness Level. In order to obtain the most credible outcome, the results obtained in the FEM analysis were combined with proven semi-empirical formulas known from the literature. This paper documents the design approach, presents the proposed structural concept and explains the method of estimating the mass of the aircraft structure using wake filling propulsion.