7 - Regional transport aircraft with regenerative propulsion

In the past few decades, there has been a large increase in aviation emissions due to the large growth of the aviation industry. The CO_2, NO_x, and sulphate emissions have contributed largely to climate change in the form of radiative forcing, and air pollution. The only way to reduce these emissions is to start operating aircraft that emit less or no greenhouse gasses, and the reduction in these emissions will have to be greater than the growth of the market. To reach lower emissions the type of powertrain will be driving and therefore new energy sources have to be explored. Also, this would heavily influence the design methods and operation of aircraft. Distributed propulsion is a design option opened up by integrating (hybrid)-electric powertrains, which can increase the propulsive efficiency. This illustrates the need for a new generation of aircraft, which would be most viable for the regional transportation market.

Mission Objective

In order to tackle the mentioned issue, a mission objective was defined. The objective is to perform a conceptual design of a regional commuter aircraft which would be able to transport at least 50 passengers including luggage, would be financially competitive to the ATR 42-600 and would be comparable to ground transport in direct operating cost. Furthermore, it would have to reduce the CO_2 and NO_X emissions compared to the ATR 42-600 by 75% and 90% respectively, have a sustainable end of life solution, have a design payload of at least 5300 kg, and operate at a DOC range of at least 400 km including reserves. A regenerative braking mechanism using electrically-driven propellers would firstly be able to harvest excess energy during descent, which would previously be lost, and secondly to allow a steeper descent profile by creating more drag. To meet all of these objectives, a (hybrid-)electric aircraft design solution will be created.

System Design

A canard aircraft with a truss-braced wing configuration, distributed propulsion, and a battery and hydrogen fuel cell powertrain system was found to offer the best performance for the mission considered. In order to derive a detailed design, the preliminary weight and sizing estimations were performed. The liquid hydrogen tanks are located in the back of the fuselage and the batteries are positioned inside the wing to relieve the bending moment. The fuel cells, together with their cooling, are podded underneath the wingtip engine. The hybrid-electric powertrain produces no direct emissions of CO_2 and NO_x. However, the formation of water vapour has been considered in CO_2e. The high aspect ratio wing is supported by a truss to reduce the wing weight. The aircraft is powered by distributed propulsion during climb to enhance the propulsive efficiency. In cruise, the inboard wing propellers are folded back, and the aircraft is powered by the tip propellers, which are sized to mitigate the tip vortex. In the last week of this project, the material selection will be performed and a life cycle analysis will be made. Also, a structural analysis including truss placement will be completed, as well as an analysis of the regenerative capabilities of the aircraft. Finally, an economic analysis will be implemented, which will break down the different aspects of the market analysis and cost.