19 - Electric General Aviation Aircraft

As the world moves away from dependency on fossil fuels, transportation industries aim to develop and implement sustainable alternatives to internal combustion engines. With aviation's continued reliance on kerosene fuels, and the growing environmental impact of the industry, a rapid development and market incorporation of sustainable aircraft solutions are sought after.

Mission Objective

This project aims to contribute to the sustainable future of aviation by developing a fully-electric general aviation aircraft, designed with a focus on minimizing lifetime emissions and providing end-of-life solutions for major subsystems. The underlying mission objective is to carry six passengers over a point-to-point distance of 500 km while utilizing electric motors and batteries as the sole source of propulsive power. Top-down restrictions also enforce sustainability goals, requiring that at least 80% of operating empty mass is reusable at end-of-life.

System Design

The strict payload and range requirements, combined with the limitations of battery technologies, result in a design driven by the battery subsystem. To minimize energy needs, efforts are focused on minimizing drag and structural mass. As a result, the aircraft follows a conventional configuration, with a low-wing, conventional tail, retractable tricycle landing gear, and two wing-mounted propellers. For all structural components, the material choice is focused on thermoplastic carbon fiber composites, representing high-performance materials with reasonable end-of-life solutions. Among the major subsystems, the project emphasizes the design of the battery, propulsion, and wing, representing critical components of the current mission.

The batteries, positioned both in the wingbox and below the floor of the cabin, are split into roughly 150 modular packs, weighing a total of 1800 kg. Each module is designed to be easily replaceable and include all supporting subsystems, such as a heat exchanger and cabling. The battery provides a nominal range of 600 km at end-of-life with additional contingencies for diversions, loitering, low-voltage systems, and degradation. The contingencies assure a high battery lifetime, with replacements planned every 2000 cycles.

Given the correlation between drag performance and battery requirements, the wing subsystem is designed to maximize aerodynamic efficiency, reducing the required battery mass at the cost of added wing structural mass. The final configuration represents a high aspect-ratio planform, limited only by internal volume and structural limitations. The chosen geometry is capable of exceptional aerodynamic performance, providing a maximum lift-to-drag ratio of 28.

The propulsion system is similarly designed to maximize performance, with two 1.8 m-diameter propellers optimized to provide more than 90% propulsive efficiency in cruise. In combination with highly efficient, lightweight electric motors, the propulsion system provides exceptional airfield and climb capabilities, with a take-off distance of less than 900 m and climb rates of around 2200 ft/min.

The final aircraft design, weighing in at around 4200 kg, represents a highly energy-efficient, sustainable, and market-competitive option for low-volume passenger transport.