HECARRUS - Hybrid ElectriC smAll commuteR aiRcraft conceptUal deSign

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ABSTRACT

This contribution is to be presented in the Clean Sky Thematic Topics session.

Aircraft electrification is seen by the global community as a major leap towards the necessary rethinking of flight, to attain specific environmental targets set by Flightpath 2050 for CO_2, NO_x and noise reduction. Small Air Transport (SAT) is characterized by the great potential to improve the environmental footprint of aviation, if electric and hybrid-electric technologies are employed in the regional, compact-air-travel aircraft of the future. In this framework, the project HECARRUS funded by the Clean Sky 2 Joint Undertaking aims to develop and integrate the conceptual design of a 19-passenger aircraft, based on hybrid-electric propulsion configurations with a targeted Entry-Into-Service of 2030.

To achieve its ambitious goal and proceed to a next step such as the detailed component design and experimental demonstration, the HECARRUS approach is built upon five main objectives, each covering one step of the value chain. Initially, the project focuses on the design and performance evaluation at sub-component (sub-systems including compressors, turbines etc.) and component (gas turbine, battery, electrical machines, heat exchangers etc.) level. The second main objective delves into the integration of components at the systems' level towards developing the entire propulsion system. The aim here is to identify all the associated challenges and opportunities that arise through the interaction of the individual systems when it comes to the level of multi-disciplinary frameworks. The third main objective of the project consists of research at the aircraft level including aircraft aerodynamics and structural disciplines. The fourth objective's purpose is to investigate the overall environmental impact of the under-studied aircraft by also including a research on the components' Life Cycle Analysis (LCA), to identify the main drivers that determine such approach when considering a hybrid-electric architecture. The last main objective intends to pave the ground for the future exploitation of the proposed design and ensure the communication of benefits and dissemination of project results.

Considering the proposed methodology of the project, its goal is to provide an integrated, 'full-loop' framework resulting in the conceptual design of the aircraft. The framework is based on already existing platforms of physics-based simulation and optimization, properly modified and further developed to match the purposes of the commuter aircraft. The scope is to provide mission level optimization of the proposed radical configurations, for state-of-the-art components integrated in the hybrid propulsion system. With a focus on the sizing and performance of the key propulsion components, aircraft structure and aerodynamics, the project aims at full design space exploration for various hybrid-electric propulsion configurations that are currently at low Technological Readiness Levels (TRL). The scope of this research contains detailed component design in key subcomponents of the powertrain such as fan/propeller, heat exchanger and wing structure design.

The main achievements of the project so far can be summarized in the following:

- Analysis and reviewing of state-of-the-art technologies of each component of the powertrain used in the field of alternative propulsion architectures of the future. The concepts are examined in terms of efficiency,

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technological readiness level (TRL), potential applicability on the commuter aircraft along with emerging challenges and opportunities.

- Identification and trade studies of Top-Level-Aircraft-Requirements (TLARs) including mission profile, range and passengers along with an analysis of the CS-23/FAR-23 airworthiness regulations available by the European Union Aviation Safety Agency (EASA) and Federal Aviation Regulation (FAR) correspondingly, for this type of aircraft.
- Generation of a ‘pool’ of aircraft concepts based on all possible hybrid-electric propulsion architectures for the commuter aircraft. The process is followed by a technology and opportunity down-selection based on a qualitative assessment where the most promising candidates have qualified for the next level of quantitative analysis including aircraft sizing.
- Aircraft conceptual sizing including proper modifications to match the hybrid-electric propulsion system architecture and coupling with automated design creation procedure via Python scripting in an open source software. This step also includes aircraft centre of gravity calculation along with static margin and trim analysis.
- Propulsive powertrain establishment of the individual modules that will constitute the base for the full-design optimization loop. These include the thermal engine (engine sizing and performance), the electrical machines (sizing and performance of motors/generators), batteries (for a range of specific power), thermal management system and power distribution and conversion.