Investigation on Regional Aircraft Configuration Variants with Distributed Propulsion using DLR's Parametric Aeroelastic Design Process cpacs-MONA

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The concept of distributed propulsion on aircraft level is getting more attention as far as aircraft with electric propulsion architectures are promising candidates to make significant progress regarding the goal of zero-emission aircraft. Besides the environmental aspects, also physics based aircraft characteristics are of interest. Basically, the disciplines aerodynamics, structure, loads, and flight mechanics are about benefit from electrically powered propellers distributed along the wing span. The paper is about to focus on the structural design, the loads of the elastic structure and the aeroelastic characteristics. The latter is especially potentially of significance as far as distributed propulsion entities are expected to cause new structural dynamic characteristics compared to conventional aircraft having two or four engines mounted on the wing.

In the project SynergIE (2018-2021, Luftfahrtforschungsprogramm V.3 of the German government) the design of a regional aircraft for about 70 passengers using distributed propulsion architecture is the main focus. In the course of the project several variants for such aircraft have been set-up using statistics based conceptual design methods. The variants comprise the number of the propellers, ranging from 2 to 12 and the wing planform characteristic aspect ratio, were varied from 14.3 to 17.

In order to improve the estimation of the structural weight, the physics-based aeroelastic design process cpacs-MONA is applied. Furthermore, the aeroelastic characteristics of aircraft configuration with distributed propulsion are investigated. Under aeroelastic characteristics the loads of the flexible structure, the control surface efficiency and the flutter behavior are understood. More evenly distributed propulsion entities along the wing span promise a better utilization of the inertia relief regarding the loads. On the other hand, the distributed masses complicate the structural dynamic characteristics and as a consequence, lead potentially to unconventional mode couplings for the flutter analysis.

In order to access the configuration variants with cpacs-MONA, the parametric aeroelastic design process has been further developed. On the structural side a parametric model of the structure housing the electric motor for the propeller has been established as well as a parametric mounting concept that allows for arbitrary positioning of the pylon structure being independent of the structural wing box, the wing's load carrying structure (FIGURE 1).

The parameter study shows a slight influence of the distributed propulsion entities on the structural weight of the wing. Furthermore, the structural dynamic characteristics of the evenly distributed propulsion entities with more than two propellers per wing exhibit a larger variety of mode shapes, but also a drastic decrease of the frequencies of some modes. The final flutter check results in classical flutter characteristics, but also unconventional mode couplings due to the frequency decrease of modes that are more affected by the frequency shift than others.

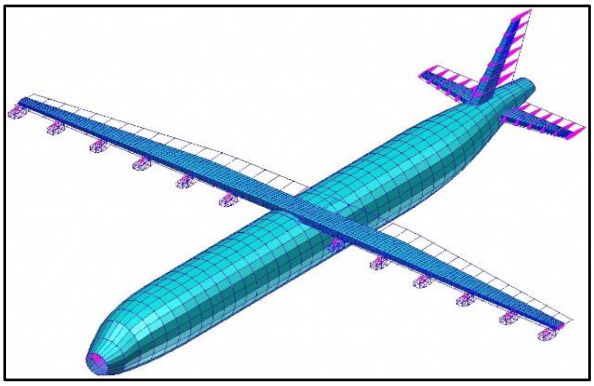

FIGURE 1 FE-Model of the 12eProp SynergIE Configuration

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