MULTIDISCIPLINARY EVALUATION OF KNOWN PROPELLER CONFIGURATIONS

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This DC project is embedded in work carried out toward multidisciplinary optimization of aircraft propeller blades. At term, a optimization method should be available based on an Evolutionary Algorithm (EA) as search engine and Artificial Neural Networks (ANN) to reduce the computational cost. Two main objectives are identified for this project:

- to build up the necessary knowledge around propellers,
- to choose/evaluate, set up and fine tune the tools necessary to make the database.

As a first step, known propeller configurations have been analysed to validate prediction packages in three disciplines: aerodynamics, aeroelasticity and aeroacoustics. They are first developed, then fine tuned and evaluated. The results are compared to the available experimental data. With these tools, other known propeller configurations can be analyzed in order to feed the database. This database lies at the root of the optimization process as it is used both to train the ANN's and to preserve previous design knowledge.

Beyond carving a correct understanding of most of the propeller related phenomena (shape, materials and assembly, flow, structural behaviour, noise sources), a correct usage of Gambit (for geometry definition and meshing), Fluent (to solve steady RANS and retrieve both macro-scale performances and emitted noise), and Samcef (for finite elements stress analysis) has been set-up.

Four different propeller configurations have been evaluated in order to scan a wide range of propellers (from legacy propellers to advanced ones). At the present, two 1950's vintage NACA propellers and two advanced propellers of the NASA SR-\textit{X} propfan family are used so that different blades are treated (thin/thick sections, wide/narrow chords, swept/unswept blade). The propellers with different loadings are considered isolated in a wind tunnel section.

Together with a mesh and domain sensitivity analysis, the aerodynamic performance of the four propellers is computed. The performance is predicted within engineering accuracy over a wide range of operating conditions. Simultaneously, the process of mesh generation and aerodynamic computations is semi-automated and the different assumptions with regard to the blade and aerodynamic model are discussed. Along with this, the two metal made legacy propellers are submitted to a limited aeroelastic study with a closer look at the root-shank assembly. Up to now, this structural analysis is restricted to plain metal blades without accounting for aerodynamic loading. Additionally, the two advanced propellers are used for aeroacoustic computations of the aerodynamic tonal noise. The Ffowcs-Williams and Hawkings analogy is used to retrieve thickness (monopole), loading (dipole) and flow (quadrupole) noise. Comparison of the computed results with both theory and experiments reveals disconcerting features, raising doubts about the implementation of the analogy in the *commercial software.*

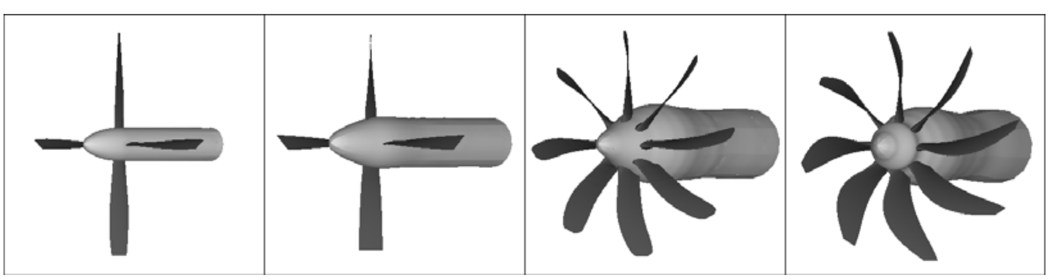

Figure 1: NACA 4-(5)(05)-041, NACA 4-(0)(03)-059, NASA SR-1 and NASA SR-3 propellers