SOUTENANCE DE THESE

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Characterisation and aerodynamic impact of leading-edge vortices on propeller blades

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Devant le jury composé de :

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Abstract:

This thesis deals with the aerodynamic properties of propeller blades. Those blades are designed to maximise cruise efficiency, while achieving target thrust at take-off. Therefore, they typically have thin, low-cambered profiles and work at high incidence at take-off, which can give rise to a leading-edge vortex (LEV).

The topology of this LEV looks similar to Delta wing LEVs, which are known to generate vortex lift. The aim of this study is to explore the probable impact of the LEV on lift at take-off in order to reconsider propeller blade designs.

The approach first consisted in characterising the LEV topology on a model blade representative of an Open Rotor front blade of type HTC5, using both Time-Resolved PIV and RANS k-omega SST calculations. The comparison between both methods demonstrated the ability of RANS calculations to reproduce the LEV characteristics of interest for this study. The LEV was found to be an elongated, near-wall structure.

An algorithm was developed to estimate vortex lift contribution from RANS wall pressure fields, and used to evaluate the impact of the LEV on lift at take-off on the HTC5 Open Rotor geometry. In order to explicit the influence of the blade's geometrical and functioning parameters on vortex lift, a 1D vortex lift model was developed and coupled to the Blade Element Momentum Theory. The first blade geometry comparative studies at iso-thrust showed that vortex lift enables to generate target thrust at take-off with a lower blade surface. This opens new perspectives for the design of blade geometries with enhanced cruise efficiency.

Keywords: LEADING-EDGE VORTEX, PIV, VORTEX LIFT, TRANSONIC PROPELLERS