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Corresponding author: MOREIRA Catharina
e-mail of corresponding author: catharina.moreira@tum.de
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Title

Wind Tunnel Experiments of an eVTOL Wing-Propeller Configuration

Authors

Catharina MOREIRA [1], Christian Breitsamter [2]*

** Corresponding author*
[1] Chair of Aerodynamics and Fluid Mechanics, Technical University of Munich, 85748 Garching bei München, catharina.moreira@tum.de
[2 1] Chair of Aerodynamics and Fluid Mechanics, Technical University of Munich, 85748 Garching bei München, christian.breitsamter@tum.de

Abstract

As the demand for efficient transportation in metropolitan areas, several innovative aircraft concepts have been proposed to meet this demand while also operating with low environmental and noise footprints. Particularly, electric vertical take-off and landing (eVTOL) vehicles have been the focus of research efforts for their capability to fit into the specific requirements for Urban Air Mobility (UAM) by combining the efficiency of fixed-wing aircraft with the maneuverability of rotary-wing vehicles. However, several technical challenges to the entry into service of eVTOL aircraft still exist. Among them, it is possible to highlight the aerodynamics of propellers under non-axial inflow and interaction between airframe and propulsion systems [1]. Previous investigations [2, 3] have explored aerodynamic characteristics of propellers operating at incidence, however, these test benches focused on isolated propellers and therefore do not account for aerodynamic characteristics of propulsion systems operating in close proximity to lifting surfaces. Especially considering vehicle concepts with tilting propulsion systems and fixed wings, it is important to better understand their aerodynamic behavior in conjunction.

In order to address this issue, a test bench for wind tunnel investigations has been developed at the Chair of Aerodynamics and Fluid Mechanics (AER) at the Technical University of Munich (TUM). The test bench is a modular subscale model of a wing and propellers systems designed specifically with the purpose of obtaining time resolved data relevant to eVTOL aircraft, particularly considering tilting rotor concepts. The model consists of a rectangular NACA4418 wing including a total of 207 pressure taps, of which 20 are equipped with transient pressure sensors while the remaining 187 provide stationary measurements. The pressure taps are distributed across 9 wing sections. In addition, the wing is placed on a 6-axis load cell for time-resolved measurements of forces and moments. Attached to the wing, a pylon is present with two electrically driven propellers also connected to load cells. The propeller placed at the leading edge can be tilted to simulate different flight conditions of eVTOL aircraft. In this paper, the details of the wind tunnel experiments and results are discussed. The pressure distribution over the wing in several different scenarios is analyzed. Load values and oscillations are presented and discussed.

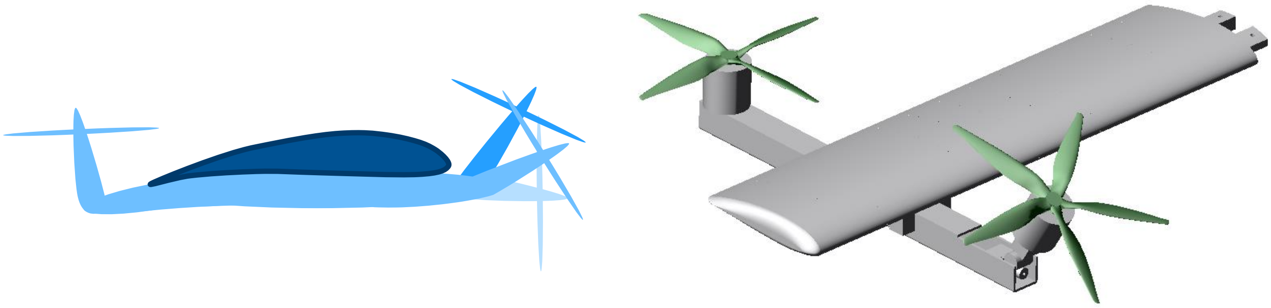

Figure 1 – Conceptual design of subscale eVTOL wing-propeller model for wind tunnel experiments, including adjustable tilt angle of leading-edge propeller. Cross section view (left) and three-dimensional representation (right).

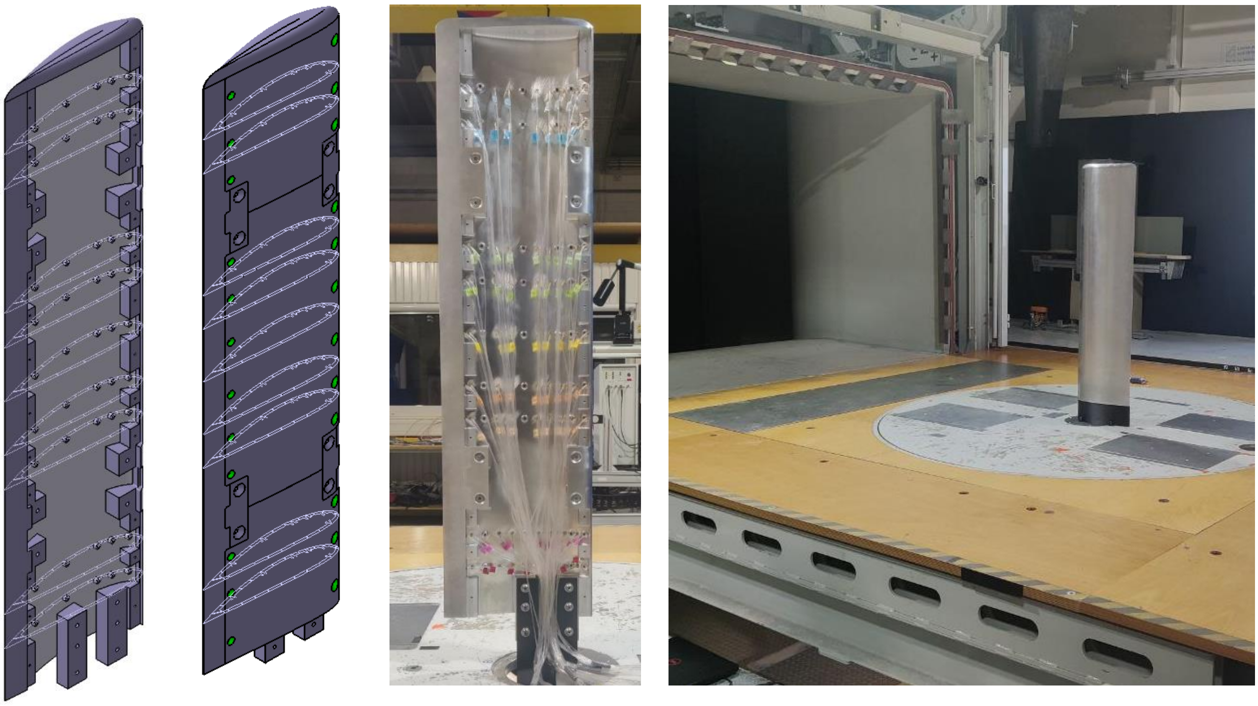

Figure 2 – From left to right: (1) CAD (computer-aided design) representation of wing model without lid panels, showing internal space for measurement equipment and 9 sections represented in white indicating the position of pressure sensors; (2) CAD representation of wing model including lid panels; (3) physical wing model without lid panels exposing the internally placed connections for pressure sensors; (4) full model placed in wind tunnel A of the Technical University of Munich.

References

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