# A CFD Investigation of an UAV Fixed-pitch Rotor in Flight Regime Transition

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Abstract:

The growing popularity and relevance of multicopter type UAVs in recent years have brought aerial vehicles closer to human lives than ever before. This is causing a pressure to lower the noise of the vehicles to more pleasant levels for human hearing. Designing a rotor with even a small decrease of aerodynamic noise could create a large competitive advantage for the UAV manufacturers.

Similarly to helicopters, majority of UAVs rely on their rotors to provide lift during the flight. But unlike helicopters which use variable-pitch blades on the rotors for flight control, multicopter type UAVs typically use differential thrust on their rotors to provide flight control. Rotors then have only fixed-pitch rotor blades. Over these blades, the flow changes are chiefly caused by changes in rotational speed, and changes in flight regimes. A typical UAV flight envelope involves many different flow conditions on its rotor blades with flight manoeuvres such as transition from hover to forward flight and back, manoeuvring at higher speeds in small spaces etc. The goal of this paper is to investigate these transitional phases to open up new possibilities of rotor blade improvement, as a large part of the rotor aerodynamic noise is associated with local stalls on the blades of the rotor that can be caused by dynamic flow condition changes.

This paper introduces a two-bladed fixed-pitch rotor in accordance with Caradonna and Tung [1], the so-called C-T rotor, in a large sphere domain simulated in the Ansys Fluent CFD software. A similar Reynolds number flow to larger multicopter UAVs is used. First the simulation is calibrated using a mesh dependency study in the hover flight condition in accordance with experimental measurements. Next a transient simulation is calculated with changing flow velocity and direction on the domain boundary, simulating the transition of the UAV flight regimes between hover and forward flight. An investigation on the flow behaviour near the blades during the transition and on the thrust, moment and acoustic noise of the rotor is done. This helps quantify the influence of flight regime transition on the possible performance of a multicopter UAV.

References:

[1] Caradonna F X, Tung C. Experimental and analytical studies of a model helicopter rotor in hover. *NASA Technical Memorandum 81232*, 1981.