M2 DET – Dynamique des fluides, Énergétique et Transferts

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PROPOSITION DE STAGE 2018-2019

Titre : Optimal control for flow energy harvesting as applied to long-endurance fixed-wing UAVs

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Sujet :

A basic example of energy extraction within sinusoidal vertical gust is illustrated in Figure 1 and will be explained further. A small UAV suddenly experience a vertical gust with a certain magnitude, at speed Uo. Since lift acts perpendicular to the local wind, the new lift vector will be tilted forward with a small additional component acting as an effective thrust. This additional lift component is performing a positive work on the aircraft and negative work on the gust. The figure also shows the case of a downdraft, where the aircraft is experiencing negative g's. This case also brings positive energy gain to the aircraft.

This project will involve theoretical analysis of the energy-harvesting mechanism of a simultaneously flapping and pitching two-dimensional wing. The conditions of flight will be taken as to match a typical mini UAV flight, while the objective of the analysis will be to determine the optimal control in the angle of attack during energy-harvesting cycles. The base flow around an airfoil will be computed using a URANS algorithm (CFD software package).

Driven by the nature of turbulence, control activation is at high frequency. Therefore, the wing will perform rapid maneuvers followed by violent variations of the angle of attack. Depending on the frequency and magnitude of pitching and heaving motions, trailing vortices are generated introducing unsteady behavior of the aerodynamic forces. In that purpose, the study should result in a determination of the energy-harvesting efficiency in function of phase lag.

The study will be based on the theoretical approach developed by Zhu [1] and Kinsey [2] compared with Navier-Stokes computations. The present study is particularly appropriate for a Master student willing to continue in a PhD program.

Time period: 5-6 months between February and September 2019

Candidate profile: Master student in Aeronautics, with major in Aerodynamics

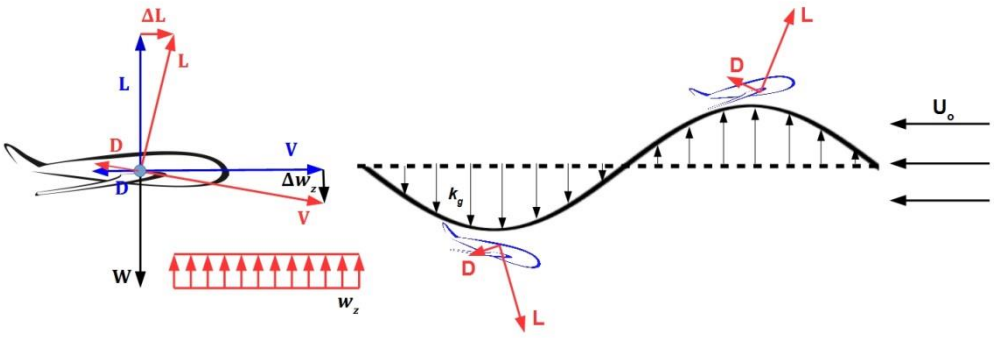

Figure 1 Gust energy extraction mechanism

References:

[1] Qiang Zhu, "Optimal frequency for flow energy harvesting of a flapping foil," *Journal of Fluid Mechanics*, Vol. 675, 2011.

[2] T. Kinsey and G. Dumas, "Parametric Study of an Oscillating Airfoil in a Power-Extraction Regime," *AIAA Journal*, Vol. 46, No. 6, 2008.