Aeroacoustic study of low-Reynolds propellers for UAV applications

Research context

Nowadays, UAVs (Unmanned Aerial Vehicle) are developing incredibly fast, both for military and commercial applications. The use of UAVs can be limited by their noise generation levels. Either for acoustic furtivity in military operations, or noise pollution in civilian use in proximity of populated areas, noise reduction of UAV propellers is a goal to achieve.

Rotor noise is a key parameter also for PAVs (Personal Aerial Vehicles), an innovative transport mode that represents a solution to provide fast urban on-demand mobility. A electrical vertical take-off and landing (eVTOL) concept of PAV developed by 3DS is shown in Fig. 1.

High fidelity CFD simulations represent a potential solution to better understand low Reynolds number flows, typical of small UAV propellers. To this aim, the software PowerFLOW will be used, which is based on a Lattice-Boltzmann method.

Figure 3. Iso-surface of vorticity magnitude of a rotor in hover (LBM data).

Experimental testing

Aerodynamic and aeroacoustic measurements will be carried out in the Anechoic Wind Tunnel at TU Delft. A test-rig for UAV propeller (Fig. 4) has been designed. The test-rig is embedded with an electric motor, an encoder, a load cell and a torque cell.

Figure 4. Left: Test-rig mounted in the A-Tunnel. Right: CAD of the test-rig.

Low-fidelity tools

Aerodynamic: Blade Element Momentum Theory (BEMT) has been chosen [2].

Acoustic: Ffowcs Williams and Hawking (FW-H) analogy [3] is used for the tonal part of noise. A trailing edge broadband model is added to enrich the acoustic prediction.

Figure 2. Blade diveded in several sections for BEMT computation.

High-fidelity simulations

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References: