

# COLLOQUIUM

Group: Engineering Fluid Dynamics

As part of his MSc thesis assignment

**Frank Gijsman**

will give a presentation, entitled:

## **Experimental Study of Flow in Wake of Robotic Bird**

**Date:** Thursday July 2, 2015

**Time:** 13:00

**Room:** Horst Building Room N.109

### **Summary:**

The Robird is a robotic bird designed and manufactured by the company Clear Flight Solutions. The Robird is inspired by the Peregrine Falcon and mimics the flapping flight of its real-life counterpart. The robotic bird is used to scare off birds by pretending to be a natural enemy. Though this robotic bird proves that flapping flight by a robot is possible, the theory behind flapping flight is not fully understood.

The goal of the present experimental study is to contribute to a better understanding of flapping wing propulsion of a robotic bird like the Peregrine Falcon based Robird. To that aim a set-up has been designed, realized and utilized for the Silent Wind Tunnel of the University of Twente.

The semi-span wind-tunnel model corresponds to the starboard side of the full-scale robotic bird, capable to operate at realistic conditions of flapping flight in which the wing carries out a combination of a plunge and a pitch motion.

In the first part of the study a 21-pitot-tube wake rake is used to measure profiles of the time-averaged velocity magnitude along traverses downstream of the wind-tunnel model for flapping frequencies in the range [2.5-4.0]Hz free-stream velocities in the range [2.5-7.0] m/s. Utilizing a control-volume analysis then gives an estimate of the time-averaged thrust produced by the robotic bird.

The results show that for Strouhal numbers above 0.1 the wake of the flapping wing has, time-averaged, a jet-like profile, associated with the generation of thrust. For increasing values of the Strouhal number, up to  $St = 0.45$ , the maximum value of the jet velocity increases.

For Strouhal numbers smaller than 0.25 a jet-like profile is found that is symmetric about the mid position of the flapping wing. For higher values of the Strouhal number the jet-like profile becomes asymmetric.

In the second part of the study a visualisation experiment is set up in the wind tunnel. Employing a smoke generator, a LED-light system and a camera the flow in the wake of the flapping wing is visualised with three streak lines. The flow pattern appears to be similar for constant Strouhal number, obtained with different combinations of flapping frequency and free stream velocity. A reversed von Kármán vortex street is found for Strouhal numbers around 0.23. In literature the reversed von Kármán vortex street is closely associated with maximum propulsive efficiency of flapping wings. At lower Strouhal numbers vortices have not been observed. At higher Strouhal numbers the vortex created during the upstroke of the wing becomes chaotic, while the vortex created during the down stroke increases in strength.

### **Assessment committee:**

Prof.dr.ir. C.H. Venner (chairman)

Prof.dr.ir. H.W.M. Hoeijmakers (mentor)

Dr.ir. G.G.M. Stoffels

Dr.ir. J.M. Hospers

**Chairman,**

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