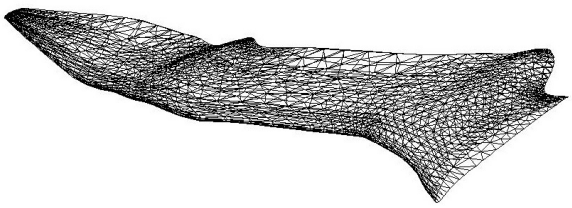
Flow Field of Flapping Albatross-like Wing and Sound at Low Reynolds Number

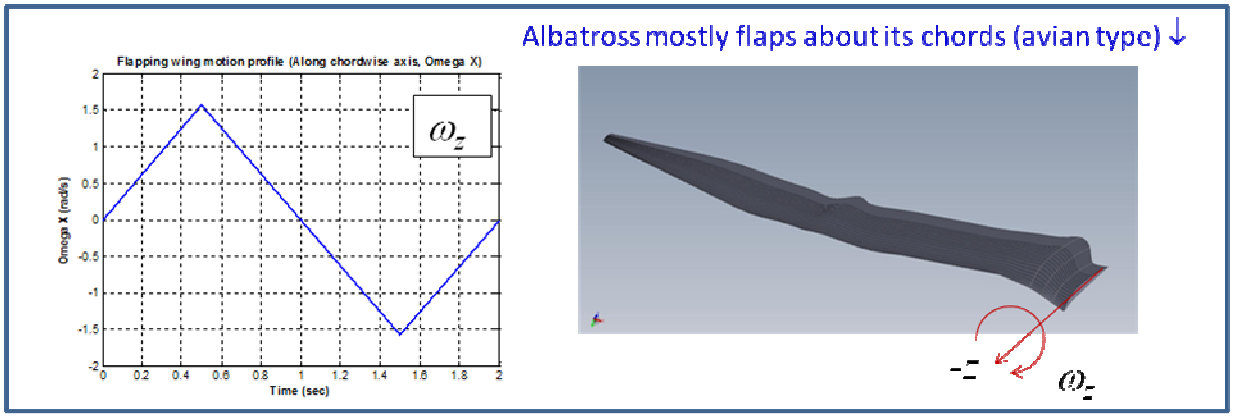
Sutthiphong Srigrarom[1*] and Chan Weoi-Leong[2]

1. Associate Professor, Aerospace Systems, University of Glasgow Singapore, Singapore
500, Blk T1A, #02-24, Dover Rd, Singapore, 139651
*E-mail: spot.srigrarom@glasgow.ac.uk (*Contact person)*
2. Research Scientist, Temasek Laboratories, National University of Singapore, Singapore
5A, Engineering Drive 1, #09-02, Singapore, 117411
E-mail: tslcwl@nus.edu.sg

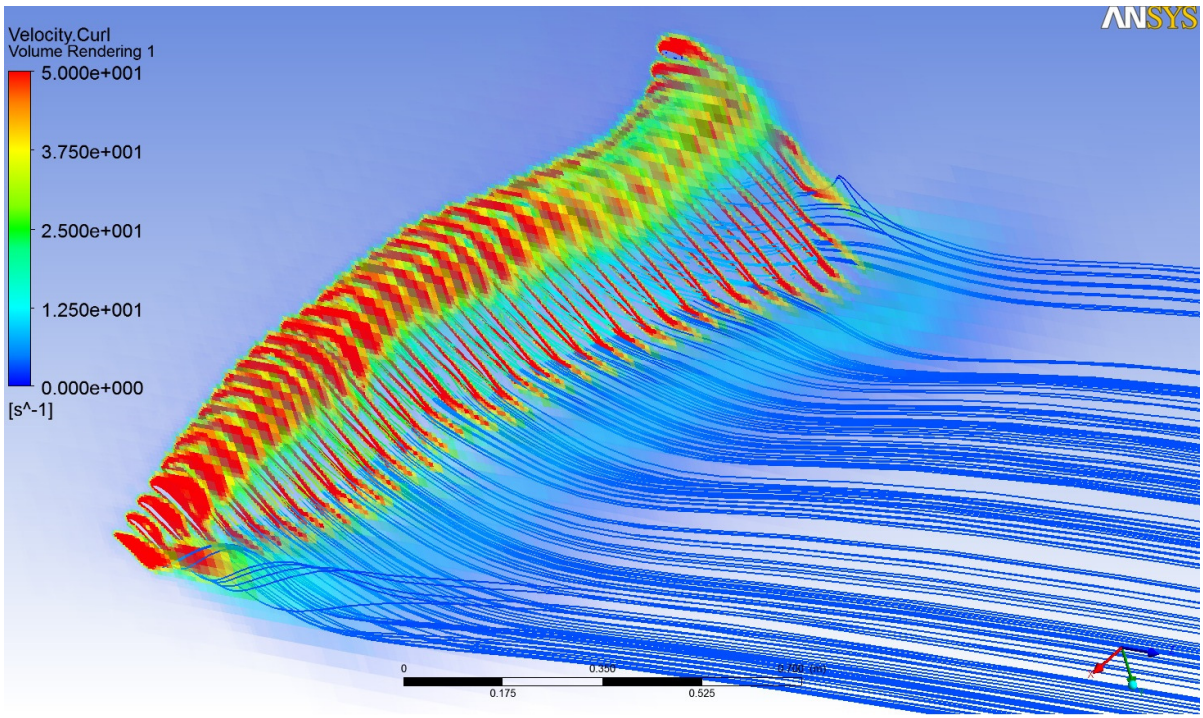
Abstract— This paper presents a part of our ongoing development of a long-distance flapping wing micro-aerial vehicle. The unsteady flow and acoustic characteristics of the albatross-like flapping wing are numerically investigated. The flapping mechanisms, flow physics and the sound generated of the albatross during start-up and cruising are significantly different. The Reynolds number based on a freestream velocity of the albatross-like wing and its chord length is Re = 25,000. The wing flaps about its chord (body axis) to mimic the avian type flapping motion. The reduced frequency of flapping is k ($\equiv \omega_z\, c/2U_\infty$) = 0.0025. The wing flaps from initial angle of attack of 0° to 45°. The flow around the flapping wing is predicted by using ANSYS Fluent® unsteady three-dimensional compressible Navier-Stokes equations, while the acoustic field is calculated by coupled ANSYS Electromagnetic solver (for low frequency sound propagation). In general, both start-up and steady state motion have similar sound patterns. At start-up motion, the large start-up vortices dominate the otherwise quiescent field with minimal sound generated. The sound is generated by the transverse and tangential motions of the wing with different sound generation mechanisms. A primary dipole tone at wing beat frequency is generated by the transverse motion, while other dipole tones at higher frequencies are produced by the vortex scattering at the trailing-edge of the wing during tangential motion. It is also found that the frequency composition of the primary tone changes with pitching angle of the wing. Whereas during steady flapping state, the wake vortices interacts, hence, the sound produced is more pronounced. The far-field sound spectrum is also more broadband.

Keywords— Flapping Wing, MAV, Albatross-like wing, Acoustic field, Sound propagation.





Albatross-like wing model and flapping patterns



Vortical flow structure the wing and the streamline. The light blue area shows the sound generating area.

.