Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: AEROFLIPHY
Corresponding author: MARIANI Raffaello
e-mail of corresponding author: rmariani@kth.se
Type: Oral
Status of corresponding author: Regular
For student corresponding author: student member of one of the following:
~~3AF / AAAR / AIAE / AIDAA / CzAeS / DGLR / FTF / NVvL / PSAA / RAeS / SVFW / EUROAVIA~~

Title
Stall Development Control of a Blended-Wing_Body UAV Using a Bioinspired Leading-Edge Design

Authors
*Carlos Neves [1], Caterina Gennari [2], Raffaello Mariani *[3]*

** Corresponding author*
[1] KTH Royal Institute of Technology, Stockholm, Sweden, cneves@kth.se
[2] KTH Royal Institute of Technology, Stockholm, Sweden, gennari@kth.se
[3] KTH Royal Institute of Technology, Stockholm, Sweden, rmariani@kth.se

Abstract
This paper presents an aerodynamic study of the stall characteristics and flow separation mechanisms of a blended wing body (BWB) unmanned aerial vehicle (UAV) being developed at KTH Royal Institute of Technology [1] and proposes a bio-inspired leading-edge modification to control the flow separation mechanism and improve the aerodynamic performance of the aircraft at high angle of attack. A numerical aerodynamic study of the aircraft was performed at cruise speed, corresponding to Reynold's number of $1.3\text{x}10^6$, employing an Unsteady Reynolds Averaged Navier-Stokes (URANS) solver with the Spalart-Allmaras turbulence model. This further study agrees with previous data [1,2], showing a baseline stall angle of 9deg and a maximum lift coefficient of ~0.82 in line with similar designs [3].

Numerical results indicated that the aircraft stall is characterized by the presence of a small separation bubble at the trailing edge – visible at the stall angle of 9deg – which breaks up into an unsteady, full-chord stall cell in the mid-span region of the wing section at an angle of attack of 10 deg. To control this phenomenon, a modification inspired by the geometry of the nose of a porpoise whale [4] was implemented to the leading edge between semi-spanwise non-dimensional sections $0.2<y/b<0.9$ – where y is the spanwise location from the aircraft longitudinal axis and b is the half-wingspan – effectively generating a porpoised ledging-edge hump. Preliminary numerical results indicate an increase in stall angle of attack to ~13deg and an in maximum lift coefficient to ~1.0. Furthermore, the porpoised hump allowed controlling the stall behavior of the aircraft by producing a larger flow acceleration extension at the leading edge enforcing a wing tip, trailing-edge separation stall.

References
[1] Suewatanakul, S. et al.: Conceptual Design of a Hybrid Hydrogen Fuel Cell/Battery Blended-Wing-Body Unmanned Aerial Vehicle—An Overview. Aerospace 2022, 9, 275
[2] Mariani, R. et al.: Wind Tunnel Test of a Blended Wing Body Unmanned Aerial Vehicle, 33rd Congress of the International Council of the Aeronautical Science, Stockholm, Sweden, 4-9 September, 2022 (ICAS-0215)
[3] Kaparos, P., Bliamis, C, Yakinthos, K.: Conceptual design of a UAV with VTOL characteristics, AIAA Aviation 2019 Forum, 17-21 June 2019, Dallas, TX, USA (doi: 10.2514/6.2019-3137)
[4] Mohamed, M.A.R. et Yadav, R: Flow separation control using the cetacean species nose design. European Journal of Mechanics, B/Fluids 2021; 89: 139–150.