Gust load analysis of aircraft wings with distributed rotors

Nicolas Maximilian Leonard Garrido, Mohammadreza Amoozgar, Mark Jabbal

Faculty of Engineering, University of Nottingham, Nottingham, UK

Modern eVTOL aviation has shifted small aircraft design toward urban applications, increasing the likelihood that these aircraft will experience larger gusts generated by organized urban architecture [1]. Because of this, understanding the gust response of the wing and the potential effects of the interactions between propellers and wings are critical to the design of these aircraft. Currently there is not much information regarding the gust loads of wings with distributed rotors, and hence the aim of this project is to investigate experimentally the influence of wing mounted propellers on wing gust response. In addition to this, the collected data will be used to check the validity of an existing numerical aeroelastic model.

A two-degree of freedom rigid wing mounted on multiple springs, to mimic the pitch and plunge motion of the wing, is developed and manufactured. The developed rig has been shown in Figure 1. The tests will be conducted in a subsonic wind tunnel with a maximum flow velocity of 40 m/s. A gust generator is used to excite the wing with different gust profiles, amplitudes and frequencies. The rig is capable of allocating of up to two rotors. The measurement system consists of high frequency displacement sensors, accelerometers, and pressure taps to capture the aeroelastic behaviour of the wing at various gust profiles and different rotor configurations.

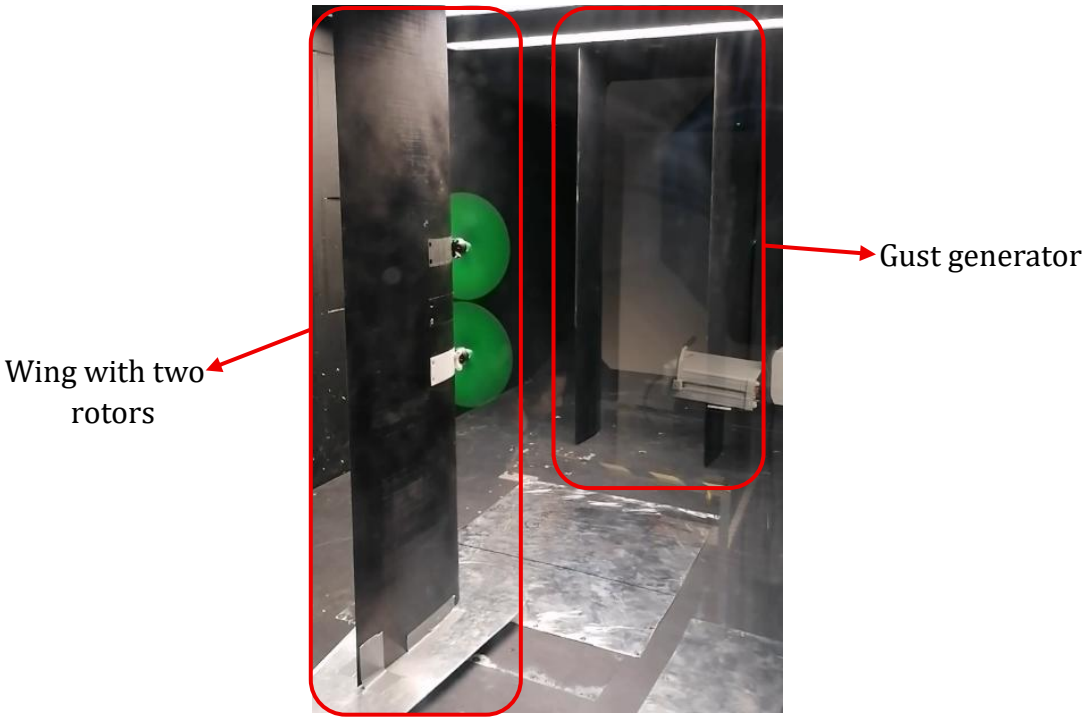

Figure 1: The developed rig with two rotors and gust generator

Initial results showed interesting aeroelastic behaviour of the wing with one and two rotors, but further tests are necessary to draw a general conclusion around this finding. The wing which

previously fluttered with one rotor became stable with two rotors when subjected to the same gust profile. The experimental results will be compared with numerical results obtained by including the effects of rotors to an existing aeroelastic model of a 2DoF aeroelastic model [2], and the validity of the model for different conditions will be assessed. The final paper will quantitatively analyse the effect of wing mounted rotors on the gust response of the coupled system to shed light for future three-dimensional mathematical model developments to predict the gust response of coupled wing- rotor systems.

References

[1] Abdulghani Mohamed et al. “Gusts encountered by flying vehicles in proximity to buildings”. In: *Drones* 7.1 (2023), p. 22.

[2] M.R. Amoozgar, A. Castrichini, S.D. Garvey, M.I. Friswell, J.E. Cooper, and R.M. Ajaj. The effect of a nonlinear energy sink on the gust response of a wing. Aerospace Science and Technology, 145, 2024.