Experimental Study of the Aerodynamic Response of a Wing Under Gusts and Ground Effect Conditions

Marcos Rodríguez[1], Clément Rouaix[1] & Horia Hangan[1]
1 Faculty of Engineering and Applied Science, Ontario Tech University, Oshawa, CANADA

Wing-gust interaction is a critical area of research aimed at enhancing aviation safety, structural strength, and fuel efficiency. As climate change progresses, both the frequency and intensity of wind gusts are projected to increase, as they are a form of atmospheric turbulence. Aircraft wings are highly sensitive to unsteady aerodynamic perturbations, and the effects of gust encounters depend on the specific characteristics of the disturbance. Large-scale gusts can induce flow detachment, whereas small-scale gusts may result in asymmetrical wing loading; both scenarios can be detrimental depending on their intensity. Although theoretical gust models are well established, they generally assume linear potential flow with low-intensity perturbations, a condition that is valid only under limited conditions. In real-world scenarios, such as low-altitude maneuvers during landing and takeoff, where the aircraft operates at low speed and at a large angle of attack, these assumptions are often violated and remain insufficiently addressed. The present study attempts to quantify and characterize the transient effects of gusts on a modern commercial aircraft wing operating in ground effect at a non-zero angle of attack and a chord-based Reynolds number of 1×10^6 with the corresponding freestream velocity of $U_\infty = 21.5\ \frac{m}{s}$. Consistent with previous numerical and experimental studies at the IMFT, the test model is an A320 non-swept wing with a chord length of 0.7 meters and a span of 1 meter. The scaled gust ratio (GR) and gust length (L_g/c) are determined in accordance with official aviation certification standards. Quantitative data will be collected using 96 pressure taps distributed along the airfoil profile, providing transient pressure measurements at three spanwise locations. Simultaneously, qualitative data will be obtained using Particle Image Velocimetry (PIV) to visualize the evolution of the spatiotemporal flow field and the mechanisms of lift fluctuations and vortical structures. The experimental campaign will be performed at the WindEEE Dome, a leading Canadian research facility specializing in atmospheric wind research. Unlike conventional wind tunnels, this laboratory can generate large-scale, spatial, and time-dependent flows that closely resemble real gusts. Furthermore, the facility enables the replication of a boundary-layer flow that is independent of the gust-generation mechanism. The experimental arrangement will employ a downward-jet profile impinging on the wing model at non-zero angles of attack and subjected also to a freestream flow, while varying the height to represent low-altitude maneuvers. This experiment will take place in Spring 2026, intending to bridge the gap in gust-wing interactions at low altitudes and to provide data to validate numerical models.

Keywords: Gusts, wing, experimental, take off, landing

Email address for correspondence: *marcos.rodriguezfrias@ontariotechu.ca*