DFD19-2019-003791

Abstract for an Invited Paper
for the DFD19 Meeting of
the American Physical Society

Unsteady aerodynamic response of rigid wings in gust encounters

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Controlled flight in unsteady environments presents a challenge that has gained interest in recent years. Unsteady flight conditions exist in many scenarios including urban areas, airwakes, and extreme weather. In cases such as these, large force transients on wings and other lifting surfaces occur due to rapid variations in effective angle of attack resulting in flow separation and the formation of large-scale vortices. The growth and motion of these vortices can have a large impact on the resulting force transient and recovery, and often requires advanced control either locally via flow control or more globally at the vehicle level. Current research efforts focus on the effect of large wind gusts that result in changes to the relative flow that are of the same order of magnitude as the freestream flow. In these large-amplitude gust encounters, flow separation is significant, so the classical linear solution for the flow does not apply. Separated shear layers emanating from the wing tend to roll up into leading and trailing edge vortices that are shed into the wake. The formation and motion of these vortices are characterized via a series of canonical experiments in an attempt to better understand their contribution to aerodynamic forcing.