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EFFECT OF IMPERFECTION GEOMETRY ON THE STABILITY OF 3D BOUNDARY LAYERS

Marco Placidi[1] **and Chris J. Atkin**[1]

[1] City, University London, Northampton Square, London, EC1V 0HB, UK

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Interest in laminar flow flight due to both economic and environmental factors has recently seen a resurgence (Tufts et al., 2017). Within this topic, the study of the detailed effect of surface excrescences on laminar/turbulent transition has received significant attention (Fage, 1943; Schlichting, 1979). However, most of the previous work has focused on the effect of steps in 2D environments (i.e. in the absence of a pressure gradient), while the effect of steps on a 3D wings has received less attention (Bender et al., 2005). Therefore, experiments on the stability of 3D boundary layers were performed in a very low turbulence wind tunnel by examining the effect of different excrescences, of a height of approximately one-third of the local displacement thickness, δ^*, located at 20% chord. Three different stepped geometries (see figure 1) are considered in order to mimic the leading edge to wing box joint characterising new concepts of laminar flow wings.

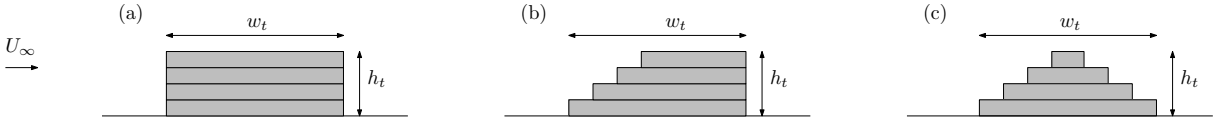

Figure 1: Schematic representation of the different step geometries. h_t represents the total height of the step, whilst w_t is total width of the step in the chordwise direction.

Results show, as expected, that all surface imperfections reduce the extent of the laminar flow region when compared to the case in the absence of a step. However, despite the severity of the excrescences, this reduction is very moderate, which suggests scope to relax current laminar flow wing tolerances. The pyramidal geometry (in figure 1c), with more gradual forward- and aft-facing steps is it found to be optimum, as the performance degradation is the lowest. Results also suggest that the different step geometries have an influence on both the excitation of the primary modes (and its harmonics) and the onset of the nonlinear phase of the instability. Further analysis will follow in the full paper.

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