EFFECT OF SURFACE IRREGULARITIES ON BOUNDARY-LAYER TRANSITION ON HLFC WINGS STUDIED BY AHLNS

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The interest in Hybrid Laminar Flow Control (HLFC) wings lies in the potential of suction for reducing the viscous drag on commercial aircraft wings by delaying laminar-turbulent transition. However, the joint between the leading edge suction panel and the wing box may introduce surface irregularities (e.g. backward/forward-facing steps (BFS/FFS), gaps, etc.). Such surface irregularities can promote transition by enhancing the spatial development of flow instabilities (e.g. Tollmien-Schlichting (TS) waves or crossflow (CF) vortices) and, therefore, may reduce the potential benefit of the suction system.

The presence of surface irregularities can cause regions of localized strong streamwise gradients in the base flow quantities. Standard methodologies for transition prediction like Parabolized Stability Equations (PSE) can still be applied in regions far from the surface irregularities, where the streamwise variations are small. However, the PSE formulation is not suited for handling the presence of such large streamwise gradients. The Adaptive Harmonic Linearized Navier-Stokes (AHLNS) equations on the other hand can handle these large streamwise gradients properly. Because AHLNS still takes advantage of the *wave-like* character of the boundary-layer instabilities by using the same wave approach as in PSE, it is able to reproduce the results from linear Direct Numerical Simulations (DNS) at orders of magnitude lower computational costs.

The AHLNS approach has already been applied to study the effect of surface irregularities on laminar nacelles at flight Reynolds numbers relevant for transonic transport aircraft. Within the European project HLFC-WIN, part of the Clean Sky 2 Joint Undertaken, AHLNS is used to assess the detrimental effects of different surface irregularities immediately downstream of the suction panel of the transonic HLFC-WIN swept-wing configuration, thus contributing to the selection of a suitable joint design and the specification of the corresponding manufacturing tolerances. As an initial result, gap geometries considered do not significantly affect the expected laminar-turbulent transition location on the HLFC system. An overview of these on-going numerical studies will be given.