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FLUTTER PREDICTION IN THE TRANSONIC FLIGHT REGIME WITH THE γ-RE$_\theta$ TRANSITION MODEL

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With increasing ecological and economic challenges drag reduction is a major topic in aircraft engineering. One way to reduce friction drag during cruise flight is to extend the laminar boundary layer on the main lifting surfaces by shifting the transition position downstream. Besides the beneficial aerodynamic effects, the aeroelastic behavior of an airfoil with delayed boundary layer transition is changed as well. So far, the flutter stability of laminar / supercritical airfoils in the transonic flight regime is not well understood.

The drag polars of laminar and supercritical airfoils show a region of significant lower drag. This *laminar drag bucket* is limited by a change in the transition region on the surface of the airfoil. Wind tunnel experiments at the DLR Göttingen on the supercritical CAST 10-2 airfoil show at a chord Reynolds number of $\mathrm{Re}_c = 2 \cdot 10^6$ a non-linear lift increase connected to a change in the transition behavior on the upper side of the airfoil [1]. The non-linear lift region has a significant effect on the unsteady aerodynamics: An aerodynamic resonance is found that is most likely connected to an instability of the transition region on the airfoil. Furthermore, the unsteady moment coefficient shows the possibility of a one-degree-of-freedom flutter. First numerical RANS computations were able to reproduce these effects qualitatively using the correlation based γ-Re$_\theta$ transition model [2]. Figure 1 depicts the computed laminar bucket for Ma = 0.72.

This paper presents additional investigations on the influence of free boundary layer transition on the flutter stability of the CAST 10-2 airfoil by numerical CFD computations in the transonic flight regime at the upper limit of the laminar bucket. For transition prediction the γ-Re$_\theta$ transition model [3, 4] is used within the DLR TAU Code [5]. The aerodynamic derivatives are obtained for pitch and heave motion and used in a flutter solver to determine the flutter boundary for classical two-degree-of-freedom bending-torsion flutter [6].

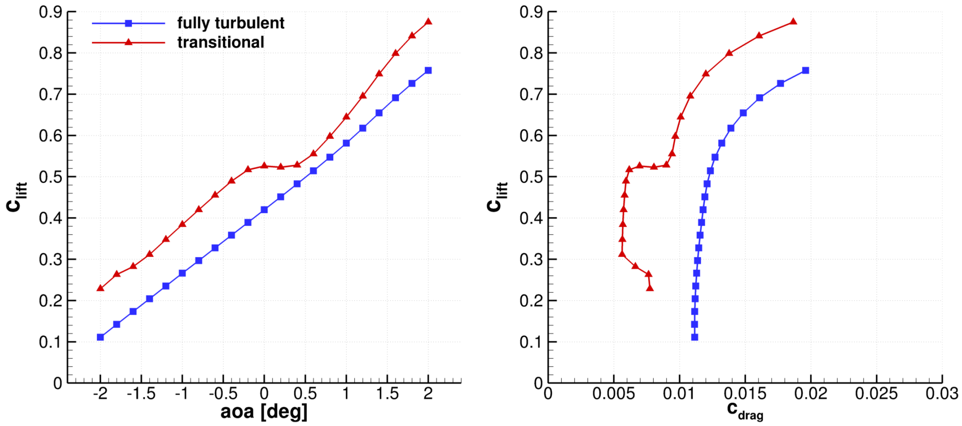

Figure 1: Lift and drag polar for Ma = 0.72 computed with the γ-Re_θ transition model: The transitional results show a non-linear lift increase connected to the laminar drag bucket.

As the upper limit of the laminar drag bucket is reached the flutter stability lowers for the CAST 10-2 airfoil. The same behavior can be found for a NACA 64-008 airfoil at the upper limit of the laminar bucket. In addition, the influence of the turbulence level on the laminar drag bucket is investigated.

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