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Boundary-layer transition in the wake of surface irregularities

JEFFREY CROUCH, The Boeing Company, VLADIMIR KOSORYGIN, Khris-tianovich ITAM, SB RAS, LIAN NG, The Boeing Company — Aerodynamic sur-faces designed for laminar flow inevitably have geometric imperfections. These im-perfections impact the unsteady processes in the boundary layer and may accelerate the laminar-turbulent transition. An experimental study is conducted to investi-gate the steady and unsteady disturbances in the wake of protruding and recessed surface irregularities, and to link these disturbances to the initial movement of the transition location. The steady disturbance field on the centerline of the irregularity is characterized by a region of velocity deficit followed by a much longer region of velocity surplus. Unsteady disturbances in the wake of the irregularity, measured prior to transition, have increased magnitudes and display a shift toward higher fre-quency. Local stability analysis is shown to capture many of the features of the pre-transitional flow. The transition Reynolds numbers collapse reasonably well when plotted in terms of the roughness height (non-dimensionalized by the boundary-layer displacement thickness). The initial movement of the transition can be represented by a reduction in the critical N-factor, consistent with a linear-amplitude based transition criterion.

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