Abstract

Micron-sized, spanwise-periodic, discrete roughness elements (DREs) were applied to and tested on a 30° swept-wing model in order to study their effects on boundary-layer transition in flight where stationary crossflow waves are the dominant instability. Significant improvements have been made to previous flight experiments in order to more reliably determine the influence that DREs have on laminar-turbulent transition. Two interchangeable leading-edge surface-roughness configurations were tested: polished and painted. The baseline transition location for the painted leading edge (increased surface roughness) was unexpectedly more aft than the polished. Transport unit Reynolds numbers were achieved using a Cessna O-2A Skymaster. Infrared thermography, coupled with a post-processing code, was used to globally extract a quantitative boundary-layer transition location. Each DRE configuration was compared to curve-fitted baseline data in order to determine increases or decreases in percent laminar flow while accounting for the influence of small differences in unit Reynolds number ($Re'$) and angle of attack ($AoA$). Linear Stability Theory (LST) guided the DRE configuration test matrix. In total, 63 flights were completed, while only 30 of those flights resulted in useable data. While the results of this research have not reliably confirmed the use of DREs as a viable laminar flow control technique in the flight environment, it has become clear that further wind-tunnel tests and computational studies, specifically direct numerical simulation (DNS) of these particular DRE configurations and flight conditions, are a necessity in order to better understand the influence that DREs have on laminar-turbulent transition.