

High-Lift Flow-Physics Flight Experiments on a Subsonic Civil Transport Aircraft (B737-100)

by

Professor C. P. van Dam
Department of Mechanical and Aeronautical Engineering
University of California
Davis, CA 95616

As part of the subsonic transport high-lift program, flight experiments are being conducted using NASA Langley's B737-100 to measure the flow characteristics of the multi-element high-lift system at full-scale high-Reynolds-number conditions. The instrumentation consists of hot-film anemometers to measure boundary-layer states, an infra-red camera to detect transition from laminar to turbulent flow, Preston tubes to measure wall shear stress, boundary-layer rakes to measure off-surface velocity profiles, and pressure orifices to measure surface pressure distributions. The initial phase of this research project was recently concluded with two flights on July 14. This phase consisted of a total of twenty flights over a period of about ten weeks. In the coming months the data obtained in this initial set of flight experiments will be analyzed and the results will be used to finalize the instrumentation layout for the next set of flight experiments scheduled for Winter and Spring of 1995. The main goal of these upcoming flights will be to measure more detailed surface pressure distributions across the wing for a range of flight conditions and flap settings, (2) to visualize the surface flows across the multi-element wing at high-lift conditions using fluorescent mini tufts, and (3) to measure in more detail the changes in boundary-layer state on the various flap elements as a result of changes in flight condition and flap deflection.

These flight measured results are being correlated with experimental data measured in ground-based facilities as well as with computational data calculated with methods based on the Navier-Stokes equations or a reduced set of these equations. Also these results provide insight into the extent of laminar flow that exists on actual multi-element lifting surfaces at full-scale high-lift conditions.

Preliminary results indicate that depending on the deflection angle, the slat and flap elements have significant regions of laminar flow over a wide range of angles of attack. Boundary-layer transition mechanisms that were observed include attachment-line contamination on the slat and inflectional instability on the slat and fore flap. Also, the results agree fairly well with the predictions reported in a paper presented at last year's AIAA Fluid Dynamics Conference.¹ The fact that extended regions of laminar flow are shown to exist on the various elements of the high-lift system raises the question what the effect is of loss of laminar flow as a result of insect contamination, rain or ice accumulation on high-lift performance.

¹ van Dam, C. P. Vijgen, P. M. H. W., Yip, L. P., Potter, R. C. "Leading-Edge Transition and Relaminarization Phenomena on a Subsonic High-Lift System," AIAA Paper 93-3140, July 1993.