DELTA WING AERODYNAMICS – REQUIREMENTS FROM CFD AND EXPERIMENTS

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The flow on a delta wing provides a real challenge for experiments and simulations. The behaviour of the leading edge vortex system that forms at high incidence can have significant impact on air vehicles. This has been evidenced in the past by buffet responses (eg for the F-18 fin) and the implications for vortex breakdown on stability and control is only just starting to be appreciated.

The paper is based on experience gained by the first author using experimental measurements and the latter authors using CFD. The state of both techniques will be summarised.

Delta wing flows have been extensively studied experimentally over the past four decades. The leading edge vortices forming over delta wings have provided a great deal of interesting and unsteady flow physics. A couple of features which have caused much controversy over the years have been vortex breakdown, and the formation of substructures in the shear layer rolling up to form the leading edge vortex.

Experimental investigations show that large scatter appears in the vortex breakdown location. Geometric variations, tunnel wall effects, support interference, model deformations, Reynolds number, and measurement technique are all possible sources of the large scatter. A further difficulty is that the vortex breakdown location is highly unsteady, exhibiting oscillations in the streamwise direction. These factors significantly affect the usefulness of the experimental data for aerodynamic analysis and design. Computational simulations may be useful in understanding the role of these factors.

For CFD, a large amount of work has been done on vortical behaviour at frequencies below those of breakdown. Reasonable agreement can be obtained with measurements of loads if careful attention is paid to the levels of predicted turbulence within the vortex. Progress is now being made in predicting the helical instability at breakdown. Calculations based on the Euler equations have successfully resolved breakdown but misplace the vortex due to the lack of a secondary separation, and generally overpredict the vortex strength. Detached Eddy Simulation is a promising technique to predict all of the regimes in a practical time.

An example of the use of CFD to aide wind tunnel testing is to investigate tunnel wall influence. A detailed study has been undertaken at Glasgow and has clarified some aspects of this problem which were problematic in the literature based on experiments.

These aspects will be expanded on in the final paper.