Paper 4.3

Investigation of the Supersonic Flow Field around a delta wing using Particle-Image-Velocimetry

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ABSTRACT

Hypersonic flight vehicles as e.g. space transportation systems are designed as delta wings. The ELAC configuration was designed as such a transport system for future orbital missions. Its first stage is a lifting-body system, which carries a second orbital stage up to an altitude of ~30 km at $Ma_\infty = 7$. At positive angles of attack flow separates near to these leading edges and generates vortices at the leeward side of the wing. The flow at the leeward side of the wing in supersonic flow is subject of this investigation. First a combination of oil-flow pattern and Vapour-Screen is applied to obtain quantitative results about the flow field. Oil flow pattern show a "fingerprint" of the flow near to the body surface. Its structure indicates separation lines and the areas of reattachment of the flow. In addition to this the Vapour-Screen method shows vortices in the flow field. Combining both methods qualitative results are obtained as shown in figure 1a. The upper part of figure 1a describes a front view of the Vapour-Screen. The dark area indicates the primary vortex, which is caused by flow separation near to the leading edge. A top view on the wing is shown in the lower part of Figure 1a. Flow separation near the leading edge and reattachment of the flow at the left hand side can clearly be seen. Understanding of the flow phenomena allows an appropriate design of quantitative measurement techniques as for example Particle-Image-Velocimetry. This technique is being used to gain also quantitative information about the velocity distribution in the flow field. Light-sheets are adjusted in main flow direction. A combination of the results from a set of measurements in parallel and perpendicular planes leads to a dataset containing all velocity components in the three-dimensional flow field. The spatial development of leading edge vortices can be therefore described. Figure 1b shows the *x*-component of vorticity, which was computed out of the measured velocities. Four planes in downstream direction depict the vorticity distribution perpendicular to the free stream direction. The applied experimental techniques are also used for validation of results from numerical simulation.

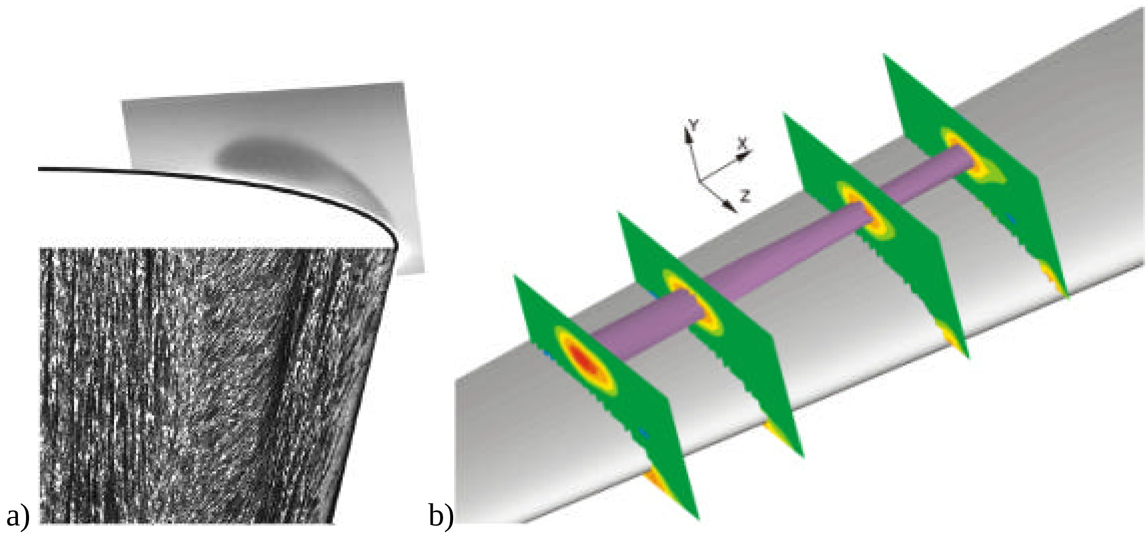

Figure 1: a) Oil flow pattern (upper part) and Vapour-Screen (lower part) at the leeward side of the delta wing configuration ELAC at $Ma_\infty = 2$, $\alpha = 10°$ at x/l = 30% ($Re_\infty = 8.9\times10^6$). b) Vorticity distribution over the leeside of the delta wing configuration ELAC in four planes perpendicular to the free stream direction and extracted isosurface of constant vorticity. Vorticity was computed out of PIV-measurements at Ma = 2 and $\alpha = 10°$ ($Re_\infty = 3.7\times10^6$).