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Time Spectral Method Applied to the Unsteady Vortex Lattice Method Coupled with Viscous Sectional Data

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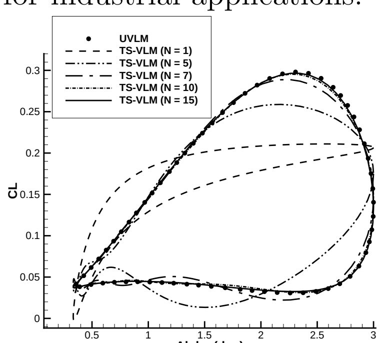
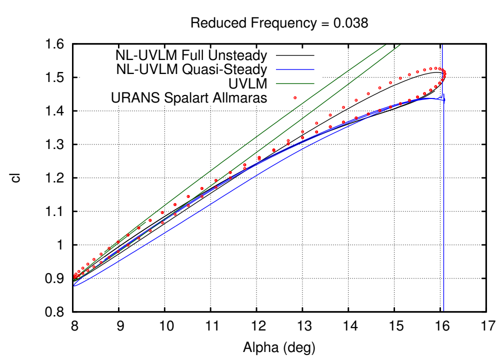
The Doublet Lattice Method (DLM) is the most widely used aerodynamic tool for aeroelastic analyses in the industry. The DLM is a linearized frequency domain (LFD) method that assumes small out-of-plane oscillations, which is not appropriate for large displacements. In the recent years, the time domain Unsteady Vortex Lattice Method (UVLM) has regained popularity for aeroelastic simulations. Its force-free wake allows non-linearities to be captured from wake roll-up and from large deflections. However, the UVLM time-domain incurs important computational costs. A new approach is proposed to solve the UVLM in the Non-Linear Frequency Domain (NLFD) by applying the Harmonic Balance (HB)/Time Spectral (TS) methods[1]. Assuming a periodic solution, the circulation is represented in time by a Fourier series with multiple harmonics. The unsteady periodic problem is solved as a steady problem yielding significant reduction in computational cost compared to the UVLM, while still maintaining non-linear effects from the wake. The left Figure shows the spectral convergence of the Time Spectral VLM (TS-VLM) for a complex pitching motion represented by $\alpha = \frac{3.0}{5.0-4.0\cdot\cos(t)}$. Finally, since the influence calculation is still performed in the time domain with the TS approach, viscous corrections[2] from sectional data can be applied to account for dynamic stall and compressibility effects. The right Figure presents an harmonic pitching motion at a high angle of attack with stall captured using a viscous coupling algorithm with the UVLM (NL-UVLM). The frequency domain formulation, combined with viscous corrections, makes the TS-VLM well suited for industrial applications.





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