Extending the Tornado Vortex Lattice Method for Stability Analysis using the CEASIOM Software

The CEASIOM Software
- Several adaptable-fidelity aerodynamic modules:
  - A handbook aerodynamic method (DATCOM)
  - Unsteady Tornado vortex-lattice code for low-speed aerodynamics
  - Inviscid Edge Euler code for high-speed aerodynamics and aeroelasticity
  - Support for external RANS codes for high-fidelity analysis of extreme flight conditions
- Quasi-analytical structural analysis methods for aero-elastic studies (NeoCASS)
- Static and dynamic stability and control analyzer together with flying-quality assessor (SDSA)
- Flight Control System design module (FCSDT)
- CAD-centric based solid geometry construction system allowing users to couple to it their own CAD and mesh generation systems.

The CEASIOM way of conceptual design

Geometry definition

Aerodynamic coefficients

Improvement of the design

Stability analysis

Possible extensions for the Tornado Vortex Lattice Method

Unsteady modes of Tornado
- Two unsteady models were compared and validated:
  - A unsteady time stepping model with a dynamic wake
  - A frequency domain model

Leading Edge Extension (Polhamus)
At large swept wings, separation occur near the leading edge. Flow rolls up into a vortex above the wing surface and increase the lift. Total Lift can be split into two parts: potential lift of the reattached flow and the vortex lift.

Conclusions
- Tornado gives good results for low speed and low angles of attack (X-31)
- SDSA + Tornado combination is a accurate way to calculate the eigenmodes (Ranger 2000)
- Both unsteady models are accurate (f-12)
- Leading edge extension works good with delta wings with small aspect ratio (high sweep angles), but not satisfying with highly swept delta wings