UAV Aerodynamics Course

Course Description: This executive course addresses fundamental principles of aerodynamics and flight stability for applications in unmanned aircraft vehicle (UAV) design. The application of theoretical aerodynamics serves to provide solutions to aerodynamic design problems formulated in Unmanned Aircraft Systems Engineering. The course provides a sound foundation in modeling and optimization, and the computation of UAV flight stability. The course is also taught online using course management software.

Instructor: *Dr Pascual Marques*
President at Marques Aviation Ltd; International Director (UK) of Unmanned Vehicle University.

Course Contents

Module 1: Introduction; Fundamentals of aerodynamics. The following topics are included: Historical perspective; Forces and moments; Centre of pressure; Aerodynamic centre; Inviscid/viscous flow; Incompressible/compressible flow; Bernoulli's Equation; d'Alembert's Paradox; Kutta-Joukowski Theorem; Circulation; Laminar and turbulent boundary layers.

Module 2: *Thin-airfoil Theory, Lifting-line Theory, Finite-wing Theory* and *Vortex-panel Method*. Classical *Thin-airfoil Theory*; Vortex sheet; Prandtl's Classical *Lifting-line Theory*; Elliptical lift distribution; Numerical non-linear lifting-line method; *Finite-wing Theory*; *Vortex-panel Numerical Method*; Numerical modeling demonstration.

Module 3: Airfoils for UAVs. Symmetric and cambered airfoils; Airfoil nomenclature; Airfoil numbering system; Modern low-speed airfoils; Natural laminar flow (NLF) airfoils; Reflexed airfoils; Concave pressure recovery; High-lift design philosophy; Selected research papers; Examples and practical applications.

Module 4: Airfoil aerodynamics. Viscous flow; Transition; Separation; Separation bubble; Real flow over airfoils; Physical features; Airfoil thickness; Airfoil experimental data; Drag polars; Camber and lift; Camber and drag; Flaps and controls; Surface roughness; Selected readings.

Module 5: Laminar and turbulent flow airfoils. Airfoil design philosophy; Velocity gradients; Separation bubble; Bubble ramp; Turbulators; Low-drag bucket; Super critical flow; Hysteresis loop; Reynolds number effects; Experimental data; Selected readings; Numerical modeling demonstration.

5 Grosvenor Road, Birkdale, Southport, PR8 2HT, United Kingdom.
Tel: +44 (0)7721 784411. Fax: +44 (0)1704 569527.
admin@marquesaviation.com www.marquesaviation.com
Registered in England & Wales with No. 7267455

Module 6: Wing planform and aspect ratio. Finite wing downwash; Win-tip vortices; Induced drag; Aspect ratio; Rectangular, tapered and elliptic planform; Lift distribution; Wing taper; Oswald efficiency; Sweepback; Forward Sweep; Canard; Delta wing and vortex lift; Wing loading; Applied examples.

Module 7: Geometric and aerodynamic twist. Washout; Washin; Induced drag; Elliptical wing planform; Stall control; Tapered planform & wingtip Reynolds number; Retained aileron function; Linear spanwise twist distribution; Optimized twist distribution; Optimized total twist; Twisterons; Review of current research. Numerical modeling demonstration.

Module 8: High-lift configurations, boundary layer stability, flow control. Multi-element wings; High-lift devices; Flaperons; Elevons; Boundary layer stability; Vortex generators; Wing fences; Downwash and induced drag; Effective aspect ratio; Effective span; Winglets and other tip devices; Applied examples.

Module 9: Adaptive wing technology and aeroelasticity. Transition delaying mechanisms; Geometric & pneumatic devices; Self-activated movable flaps; Effective wing geometry; Variable sweep; Variable leading/trailing edge camber; Contour bumps; Flaps; Slats; Air jet; Sub-boundary layer vortex generators; Aeroelastic wing twist; Flexible wing; Twisterons; Wing flutter; Morphing; Applied examples.

Module 10: Rotorcraft aerodynamics. Helicopter UAVs; Rotor thrust; Rotor drag, Coning angle; Disc loading; Helicopter flight principles; Ground effect; Translational lift; Autorotation; Vortex ring state; Blade & blade tip design; Rotational airflow; Blade tip speed; Retreating blade stall; Blade flapping; Blade sailing; High-inertia blades; Tip sweepback; Anti-torque rotor design; Applied examples.

Module 11: CFD fundamentals. Creation of geometry; Mesh generation; Boundary conditions; Numerical solution; Review of current research.

Module 12: Automated flight stability; Course summary. Static stability; Dynamic stability; Longitudinal stability and control; Neutral point; Static margin; Elevator effectiveness; Lateral stability and control; Directional stability and control; Stability derivatives; Pitching, rolling and yawing rate; Inertial and aerodynamic damping; Canard; Forward wing sweep; Stability augmentation; Practical examples.

5 Grosvenor Road, Birkdale, Southport, PR8 2HT, United Kingdom.
Tel: +44 (0)7721 784411. Fax: +44 (0)1704 569527.
admin@marquesaviation.com www.marquesaviation.com
Registered in England & Wales with No. 7267455