Editor's Technical Note

IJUSEng – 2013, Vol. 1, No. S1, 3-4
http://dx.doi.org/10.14323/ijuseng.2013.2

Emerging Technologies in UAV Aerodynamics

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Abstract: Marques P. (2013). Emerging technologies in UAV aerodynamics. *International Journal of Unmanned Systems Engineering*. ***1***(S1): 3-4. Novel unmanned aerial vehicle (UAV) technologies address innovative airframe concepts for reasons of fuel efficiency, aircraft noise signature attenuation and reduced maintenance costs. New aerodynamic technologies prioritise flow control and flapless designs, in place of traditional hinged control surfaces, for enhanced manoeuvrability, reduced wing structural weight, and improved stealth. This technical note presents contemporary advances in *Blended Wing Body* (BWB) airframe design and flow control mechanisms for flapless flight control. Based upon the Coandă effect, *engine thrust vectoring* provides pitch control and *Circulation Control* (CC) replaces conventional ailerons for roll control. The integration of flapless aerodynamic technology in blended wing-body aircraft is envisaged to play a crucial role in future experimental flight research programmes for the development of next generation UAV concepts.

Keywords:
Aerodynamics
Blended Wing Body
Boeing X-48
Circulation Control
Coandă effect
Demon UAV

1. BLENDED WING BODY DESIGN

The *Blended Wing Body* concept offers promising advantages in structural, aerodynamic and operational efficiency over the conventional fuselage-and-wing designs (Fig. 1).

The unmanned Boeing X-48 Blended Wing Body experimental aircraft represents the futuristic philosophy supported by Boeing and NASA that a blended or hybrid wing-body concept offers the long term solution to fuel efficiency and noise reduction[1]. A blended wing body aircraft consists of a modified delta design that blends the vehicle's wing and body into a smooth con-

Fig. 1: Boeing's X-48B Blended Wing Body technology demonstrator.
Photo: Tony Landis for NASA.

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figuration. Recent flight tests at NASA's Dryden Flight Research Center at Edwards Air Force Base show that a blended wing-body aircraft can be controlled effectively at the low-speed flight regimes during takeoff and landing. Relocation of the wingtip winglets inboard near the engines in the *X*-48*B* and *X*-48*C* versions effectively shifts their role from winglets to twin tails and provides evidence that in an advanced Blended Wing Body UAV noise attenuation takes priority over the traditional augmented effective span and aerodynamic efficiency of the wing by means of winglets (Fig. 2).

Fig. 2: NASA-Boeing X-48C with inboard vertical stabilisers. **Photo: Carla Thomas.**

2. CIRCULATION CONTROL BY COANDA EFFECT

The 5-year FLAVIIR project is a comprehensive research program that addresses technologies for next generation UAVs. The technical research comprises 7 areas: Aerodynamics, Control systems, Electromagnetics, Manufacturing, Materials/ Structures, Numerical simulation and Integration. The £6.2M project is administered from Cranfield University and funded jointly by BAE SYSTEMS and EPSRC. An iconic feature of future UAV design is aircraft control without conventional control surfaces. In the context of the FLAVIIR project, the Demon UAV by BAE Systems incorporates a novel aerodynamic 'flapless' control system that utilises engine exhaust thrust vectoring and bleed air to generate the aerodynamic forces and moments usually provided by flaps, ailerons and elevators. While flaps and other control surfaces are effective at increasing the wing lift coefficient, they do so at a higher drag cost. Instead, fluidic flight controls direct air from a rectangular exhaust nozzle over Coandă surfaces to provide pitch control[2].

Similarly, bleed air blown over a Coandă surface embedded on the trailing edge of the wing, in place of conventional mechanical ailerons, is used for roll control. Recall that the Coandă effect, named after Romanian aerodynamics pioneer Henri Coandă, is the tendency of a fluid jet to be attracted to a nearby surface. The novel Coandă effect flow-control technology is termed *Circulation Control*. A Circulation Control system uses of a fixed-geometry lifting surface with a circular trailing edge cross section. Air is blown tangentially over the curved trailing edge to adjust the location of trailing edge flow separation. This produces a change in wing circulation and allows modification of the lift coefficient without the need to alter angle of attack. In addition, the aerodynamic circulation control system modifies the characteristics of the boundary layer and provides greater lift or drag necessary for take-off and landing.

Research programmes that attend to the integration of flapless aerodynamic technology in hybrid wing-body aircraft will allow efficient flight control without the use of conventional control surfaces in next-generation UAVs.

3. REFERENCES

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