High Fidelity Aerodynamics Models for Blended Wing Body Design

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Researchers and engineers have been carrying out many different studies on the Blended Wing Body (BWB) in the last twenty years. The aerodynamics properties of this aircraft configuration are seen by many as a possible way to decrease fuel consumption and improve performances in civil aviation [Liebeck 2004]. However, the unconventional shape of the BWB poses many challenges when it comes to aerodynamics calculations, especially when they are performed in the frame of a multi-disciplinary approach, in early stage design. High computational efficiency must be coupled with adequate fidelity and robustness in the results. Besides, the choice of design variables becomes more than ever of fundamental importance [Qin 2004, Lyu 2014].

The goal of this project will be to validate low fidelity aerodynamics models for Blended Wing Body configuration, performing computations on ISAE-ONERA BWB geometry. 3D low fidelity methods are based on inviscid equations and lifting-line theory. In the Vortex Lattice method (VLM), for instance, the thickness of the wing is neglected and the surface is divided into many panels, on each of which a horseshoe vortex is placed and boundary conditions must be locally satisfied. These techniques are more reliable in subsonic conditions, but could be expanded with corrective terms in transonic flight. Being more cost efficient than Navier-Stokes equations solvers, low fidelity methods are widely used in preliminary design and have already been applied to BWB optimization [Qin 2004]. Vortex-Lattice simulations will be performed with open source software OpenVSP [OpenVSP 2018].

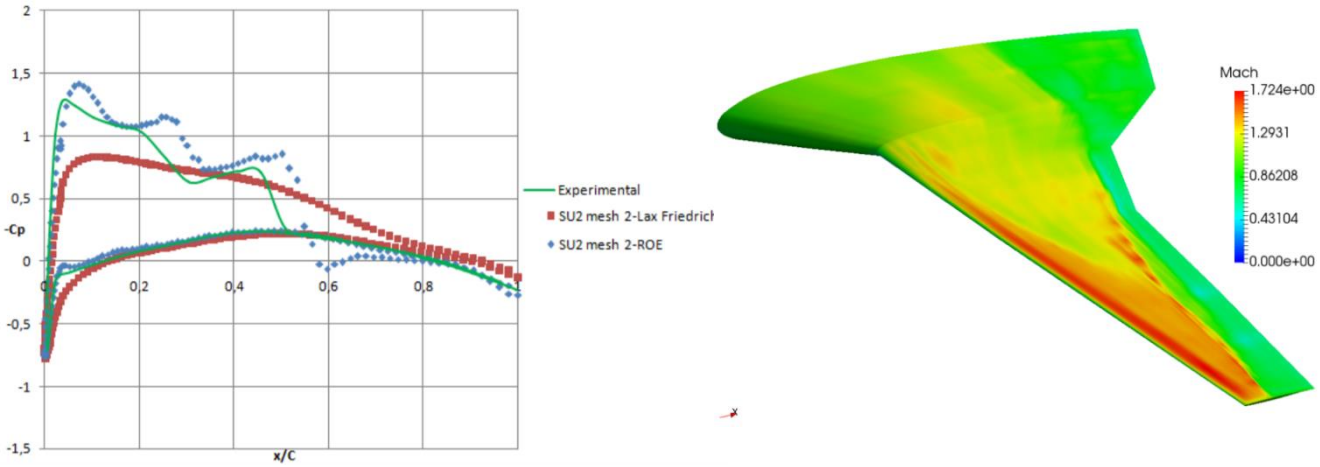


Figure 1 (left) – Validation of SU2 computations with Experimental results on ONERA M6 wing

Figure 1 (right) – Examples of SU2 computations on BWB geometry using SU2 [Garcia Cepeda 2018]

Validation of VLM low fidelity models will be carried out by comparison with higher fidelity methods, such as Euler equations finite volume solver. The designated tool is SU2, an open source collection of software able to perform both viscous and inviscid CFD computations [SU2 2018]. A meshing of ISAE-ONERA BWB geometry has already been obtained with ICEM [ANSYS 2018]. Simulations will be performed at different angles of attack α and Mach numbers, in order to create a suitable database for comparison and validation. Different

numerical methods (such as Lax-Friedrich and ROE numerical methods) will be implemented and compared to best represent classical transonic phenomena like shock waves and wave drag [Ferziger 2002]. Aerodynamics curves ($C_L - \alpha$, $C_D - \alpha$, and $C_L - C_D$) will be drawn as well. Together with low fidelity methods, analytical expressions for BWB aerodynamics properties (such as Jones Theory for low aspect ratio wings) will be tested by comparison with SU2 Euler simulations.

The final phase of the project will be to conclude on the reliability of low fidelity aerodynamics models and analytical formulations, and assess the possibility to introduce them in Blended Wing body design, to improve cost efficiency while preserving an acceptable degree of accuracy.

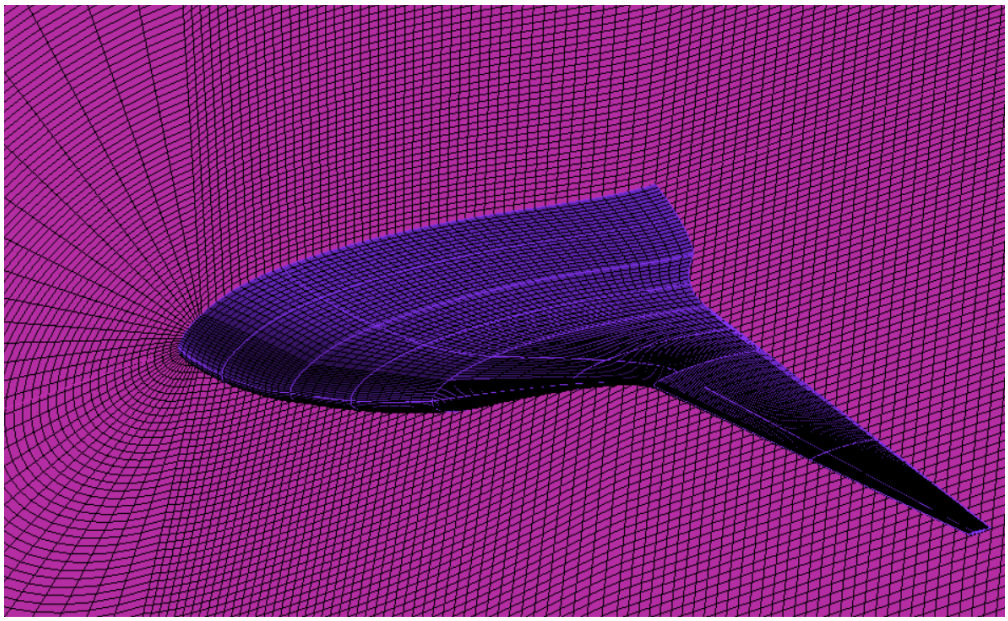


Figure 2 – Meshing of ISAE-ONERA Blended Wing Body geometry.

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