Analysis for a wing nacelle configuration

*Marwan ISPER, **Mihai Victor PRICOP, ***Daniel CRUNTEANU

* ***Aerospace Engineering Faculty, UPB, Str. Gheorghe Polizu, NR. 1, 011061, Bucharest, Romania, marwan_jb@yahoo.com
**Corresponding author,
INCAS - National Institute For Aerospace Research "Elie Carafoli"
Bdul Iuliu Maniu 220, Bucharest 061136, Romania
vpricop@incas.ro
DOI: 10.13111/2066-8201.2010.2.2.12

Abstract: *The paper presents CFD results for a wing-nacelle configuration, in order to be tested against an analytic solution considering nacelles as chord discontinuities.*

Key Words: *Aerodynamics, CFD, wing nacelle*

1. INTRODUCTION

The paper presents CFD results (RANS) for the case of a wing-nacelle configuration. The flow regime corresponds to Mach 0.3 and Reynolds 30 million. The flow-field is analyzed with Fluent. Pressure profiles are presented both transversal and longitudinal, in order to be further compared against analytical results. Spalart-Allmaras turbulence model has been used.

2. MODEL

The reference model is resembling the B-57 wing. The airfoil is RAE 103(symmetric), scaled to 12% relative thickness for the inner wing panel, and 9% for the wing tip (-0.5 deg twisted). Three configurations were prepared, empty nacelle, corresponding to an engine and fuel tank nacelle.

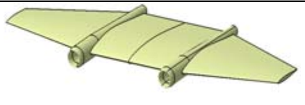
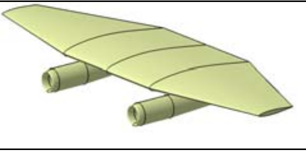
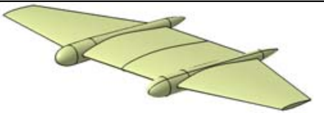
		

Fig. 1 First configuration with jet-engine nacelles	Fig. 2 Second configuration with under wing nacelles	Fig. 3 Second configuration, with tank-like nacelles

Geometrical models were built in CATIA V5. The RAE 103 airfoil is least squares reconstructed using a trailing edge constraint: a thickness of 0.3% is imposed, by a linear increment along the chord line. The interpolation basis is:

$$F(x)^T = \left(\sqrt{x} \quad x \quad x^2 \quad x^3 \quad x^4 \quad x^5\right)^T.$$

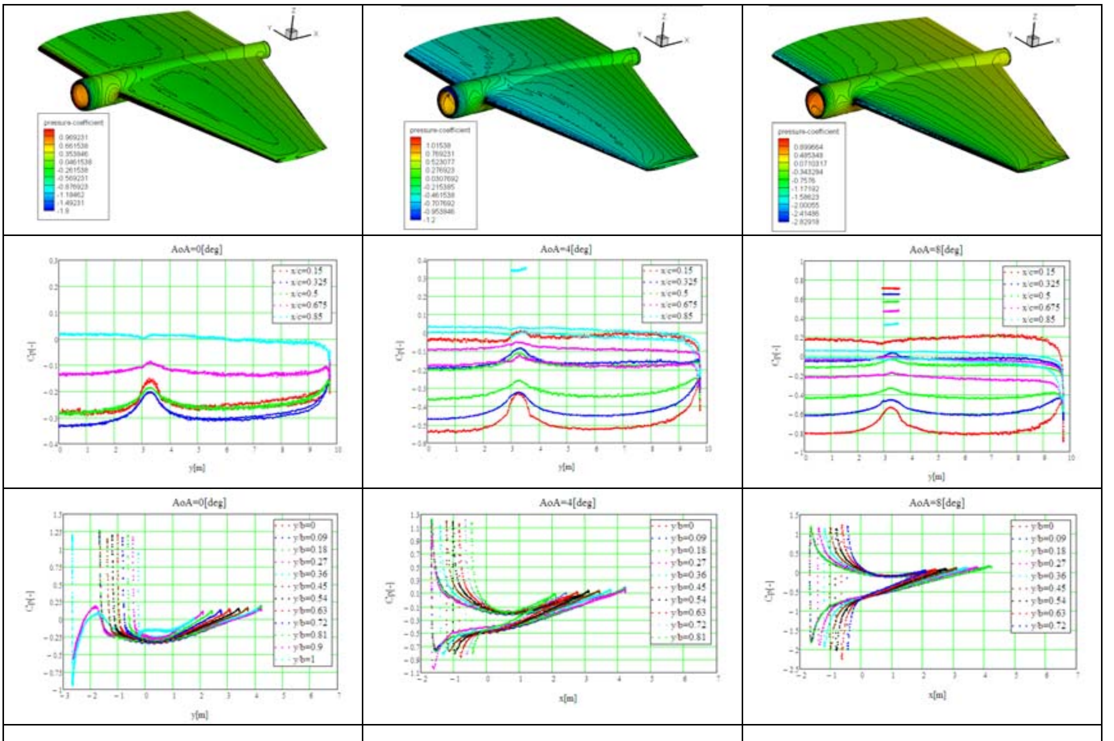
The airfoil thickness is $t(x) = F(x)^T \cdot C$, where

$$C^T = (0.12238 \quad -0.07333 \quad 0.21645 \quad -0.7334 \quad 0.66822 \quad -0.19882)^T$$

Unstructured tetrahedral meshes have been used, to save preparation time. SIMPLE second order scheme was used.

A FORTRAN routine has been written to extract Cp or other wall values along constant chord percentage lines, since this capability is not available in the code we have used.

3. NUMERICAL RESULTS



a) b) c)

Fig. 4 Pressure profiles for the first configuration: a) 0deg, b) 4 deg and c) 8 deg

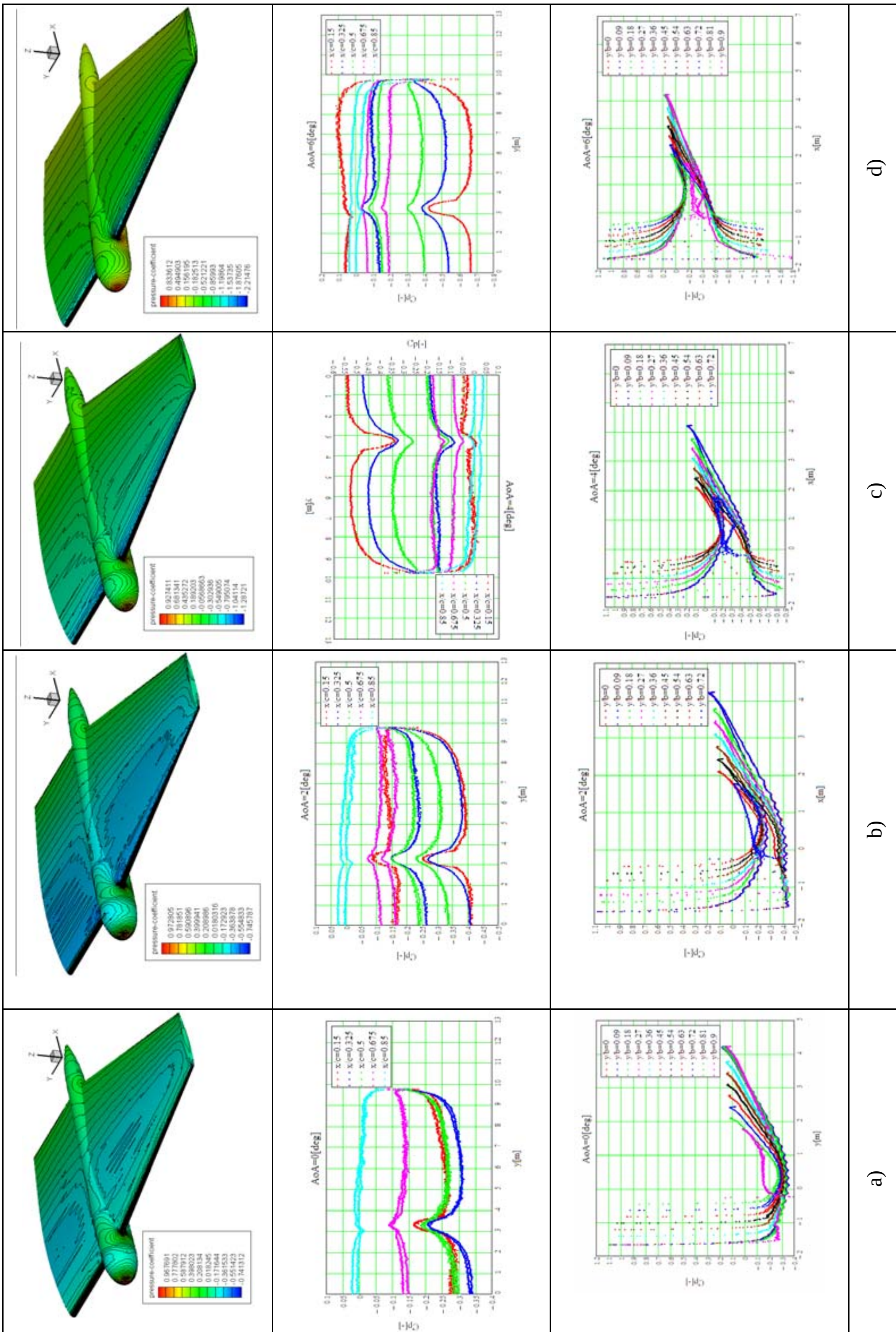


Fig. 5 Pressure profiles for the second configuration: a) 0 deg, b) 2 deg, c) 4, deg, d) 6 deg

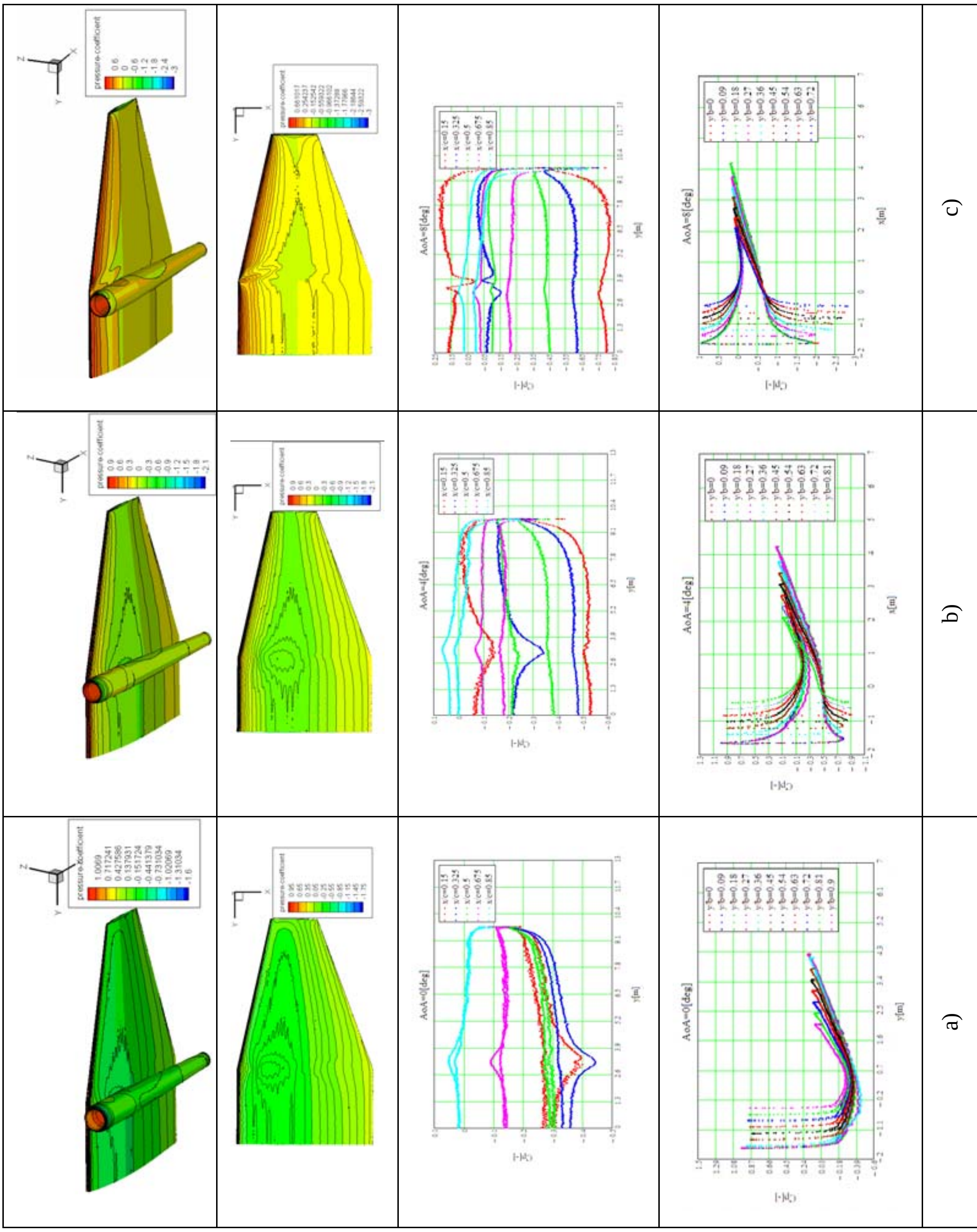


Fig. 6 Pressure profiles for the third configuration: a) 0 deg, b) 2 deg, c) 4, deg,

4. CONCLUSION

Chord-wise and span-wise Cp profiles are consistent. When the Angle of Attack is zero, there is a small difference between upper and lower surfaces. In this respect, the first configuration is the most accurate. Outer wing twisting creates a slight asymmetry in pressure, even at 0 deg. While the first two configurations are clearly similar, the third configuration is different. Here we have a clear effect of the nacelle onto the lower side and an influence in zero lift axis/pitching moment.

Pressure oscillations are visible, but we suppose their effect is not important for global force/pitching moment. They are related to the unstructured mesh numerical effect, or solver parameters.

Pressure profiles will be compared with the results from an analytical method, as future work.

REFERENCES

[1] ANSYS FLUENT 12.0 Theory Guide, 2009
[2] ANSYS ICEM CFD/AI*Environment 10.0 User Manual, 2005