UTILIZATION OF OPEN SOURCE SU^2 CODE ON SACCON STABILITY AND CONTROL CONFIGURATION

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Summary. *This study is carried out with the open source code SU^2 for calculating the flow field around the generic unmanned combat aircraft SACCON configuration that was used as a test case in the NATO AVT 161 working group. A 53˚ sweep angle is specifically examined in terms of aerodynamic characteristics. CFD analyses are conducted at low subsonic speed regime and at high angles of attack up to 15 degrees. It is observed that the SU2 CFD results are compatible with the experimental results.*

1 INTRODUCTION

Stability and Control Configuration (SACCON) is introduced by NATO AVT-161 working group as a primitive UCAV testbed for calibration and validation of CFD tools for fighter configurations. Schüette et al. [1] examined its geometry for understanding the Reynolds number, leading edge sweep angle and the Mach number effects. The results are compatible with the wind tunnel experiment. Loeser et al. [2] conducted static wind tunnel test for the φ=53˚ sweep angle. Test model has interchangeable leading edge structure and flaperons. Model span length is 1.54 m and projected wing area is 0.77 m^2. Test model is instrumented with six component force sensor and 230 flush-mounted pressure transducers. The tests are conducted at free-stream velocities of 50 m/s and 60 m/s, angle of attack range of [0˚, 30˚] and angle of side sleep range of [-10˚, +10˚]. Effect of sting position on stability and control is also studied. It is concluded that belly sting has significant effect on lift and pitching moments whereas its contribution on drag is found to be negligible. Morgand et al. [6] and Konrath et al. [7] examined static and dynamic SACCON PIV tests for forward flow field and aft flow field. Loser et al. [8] conducted wind tunnel tests for SACCON forced oscillation simulation at DNW-NWB and NASA LaRC wind tunnels.

2 NUMERICAL METHODOLOGY

The compressible Reynolds-averaged Navier Stokes (RANS) equations [5] are solved with SU^2 that is an open-source CFD suite developed by Stanford University. SU^2 is developed in C++. The main functions of the software are design and grid optimization. Software works with a parallel computation Python code. This code runs SU2_CFD in a parallel fashion. When the computation is finished, SU2_SOL code is run in order to obtain surface and volume data. [4]

The solver type is selected as approximate Riemann solver (Roe scheme). The spatial discretization is handled through first order upwind scheme. The turbulence model used is the two equation kω-SST [3] model. Steady state simulations are performed for four different angle of attack values (0˚, 5˚, 10˚, 15˚) at a Mach number of 0.181 and Reynolds number of, Re= 1.89 10^6. Parallel computations are performed on 800 cores. Simulation of flow with 27.3 million elements takes one hour and 38 minutes for 6000 iterations.

shows the SACCON geometry and its specifications. The model is rotated in pitch axis around the given point-of-rotation and the forces and moments are calculated at the Moment Reference Point (MRP).

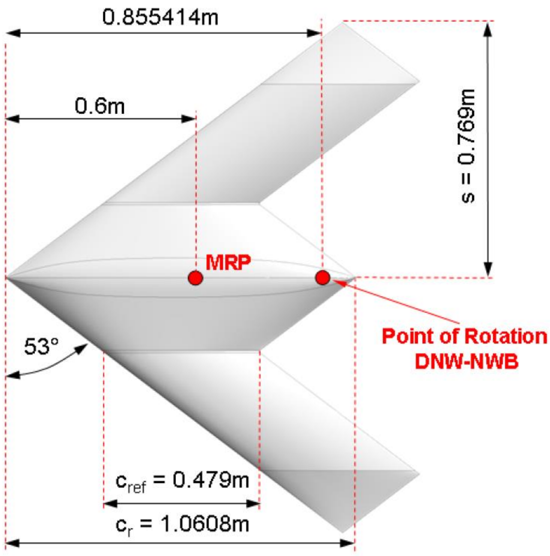
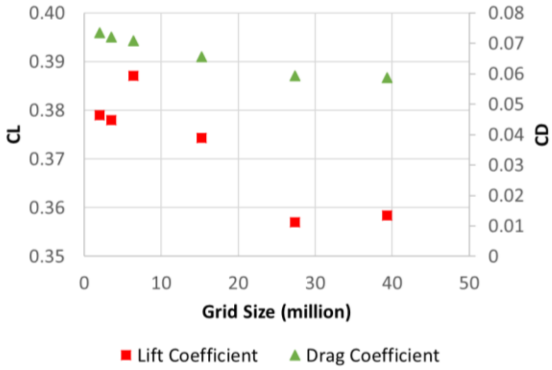


Figure 1: SACCON Reference Values and Geometry

Figure 2 shows the grid independency study performed using six grids, generated by ANSYS

17.0 [9], with 1.96M, 3.48M, 6.40M, 15.23M, 27.39M and 39.36M elements. It is seen that grid with 27 M elements gives similar results with the grid of 39.36 M elements in terms of lift and drag; therefore, it is concluded to continue the study with the grid of 27.39 M elements given in Figure 3. First layer thickness is calculated as 6 x 10^{-6} m considering the y+ value is 1. After the formation of the boundary layer, last layer thickness size is applied for the whole body of influence geometry that is located around upper portion of the wing-body configuration.



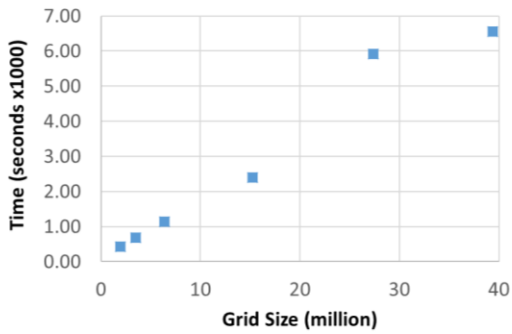
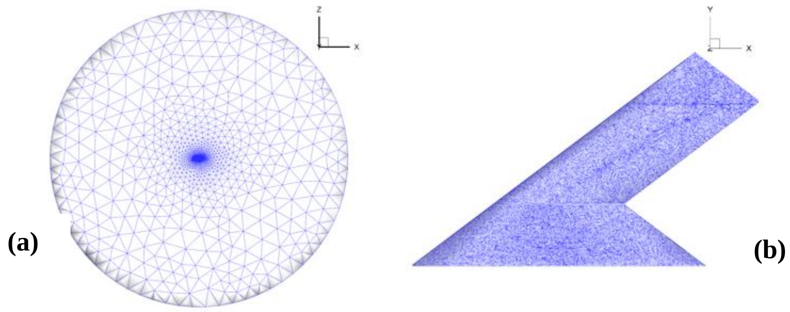


Figure 2: Grid independency study



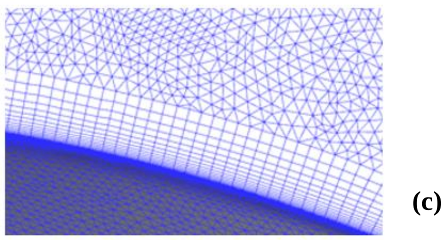


Figure 3: Computational grid around SACCON model (a) Overall grid, (b) Surface grid on right-half of the model, (c) Boundary layer grid

Figure 4 shows the comparison of the preliminary CFD results with experiments. Lift and drag coefficients increase with increasing angle of attack. However, at an angle of attack of 11 degrees, the moment coefficient values decrease dramatically. The reason is the inner vortex which starts from the leading edge of the wing and also secondary weak vortex that comes from suction portion of the wing. This drop continues up to an angle of attack of 15 degrees.

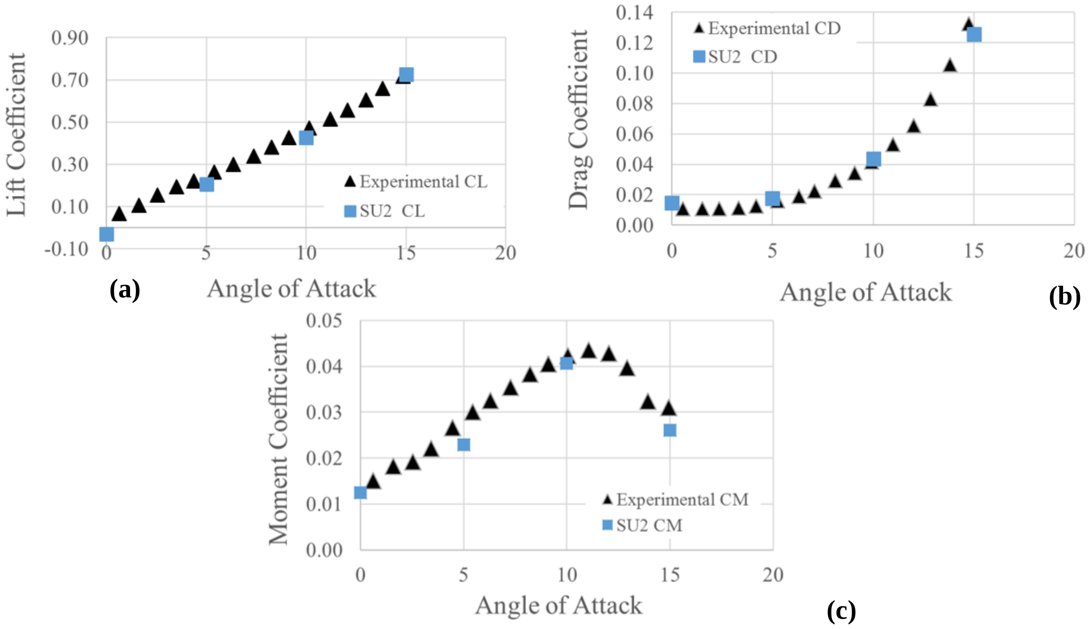


Figure 4: (a) Cl vs α, (b) Cd vs α, (c) Cm vs α

3 CONCLUSION

In this study, flow around a simplified UCAV geometry at M=0.181 and Re=1.86 10^6 is solved with an open-source CFD solver SU^2. The maximum difference between the experimental and numerical results are found to be 10%. Aerodynamic forces and moments gathered by SU^2 agree well with the experimental results. It is also observed that SU^2 can accurately capture highly vortical flow on the upper-side of the SACCON geometry.

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