Case C2.1

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September 30, 2011

1 Code Description

The solver utilized in this work is a high-order discontinuous Galerkin(DG) solver. The solver can solve the Euler, Navier-Stokes,and RANS equations in two dimensions. The equations are solved using a fully implicit Newton solver which uses GMRES as the linear solver. For this case a colored Gauss-Seidel preconditioner is used. The solver is parallelized using MPI where METIS splits the meshes for parallel processing. Uniform mesh refinement at $p = 2$, $p = 3$ and $p = 4$ is considered for this case. The time stepping scheme is a four stage third order implicit Runge-Kutta(ESDIRK3).

2 Summary

In all cases the residuals for the flow and adjoint equations are converged 12.5 order of magnitude. The machine used in this work is a Linux cluster with AMD 8132 Magny Cores processors at 2.3 GHz. The number of cores used is 32 for all runs. The taubench timing result for this machine is not known(it could not configure on the machine). For a reference the work units in this case will be determined using $T_1 = 9.47$.

3 Meshes

- The domain is 200x200 chords with the farfield boundary located at 100 chords from the airfoil surface. The farfield boundary condition is characteristic in/out-flow.
- The meshes are fully unstructured mixed element meshes. Table 1 gives the spatial and temporal resolution as well as work units for each order of accuracy considered.
- Uniform mesh refinement across a sequence of 3 meshes was performed and the presented results are from the finest mesh at each order of accuracy.
- During refinement the curvature remains constant because the mesh is initially curved to suitably high order($p_{curve} = 5$). Uniform refinement is accomplished via 4:1 isotropic splitting of the elements.
- The meshes are curved by using the geometry definition from the mesh generator which gives extra points on the boundary for curvature. Anisotropic meshes are curved by curving the lines used in the line-implicit linear solver.

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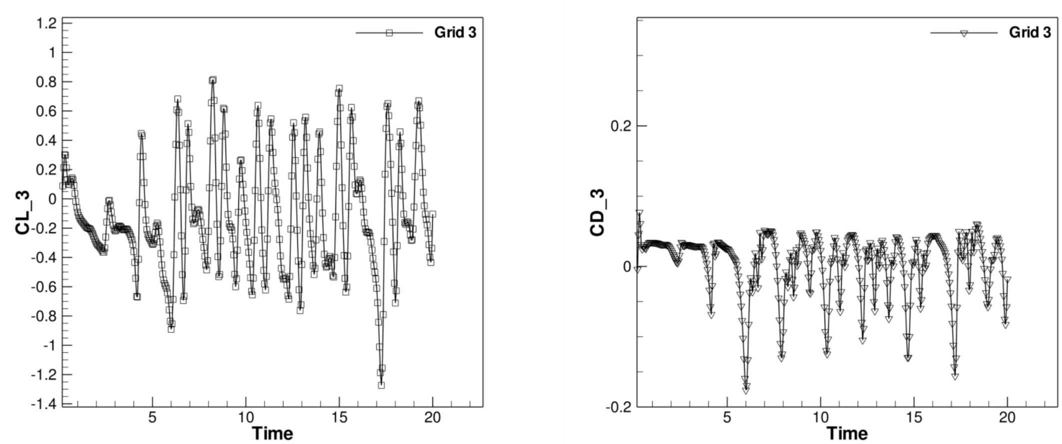
Table 1: Resolution for each order of accuracy

p	N_{DoF}	Δt^*	Work Units
2	$390,000$	.05	$25,756$
3	$662,656$	.05	$57,999$
4	$251,660$	.05	$26,309$

4 Results

4.1 Case C2.1-A: Smooth Initial Condition A

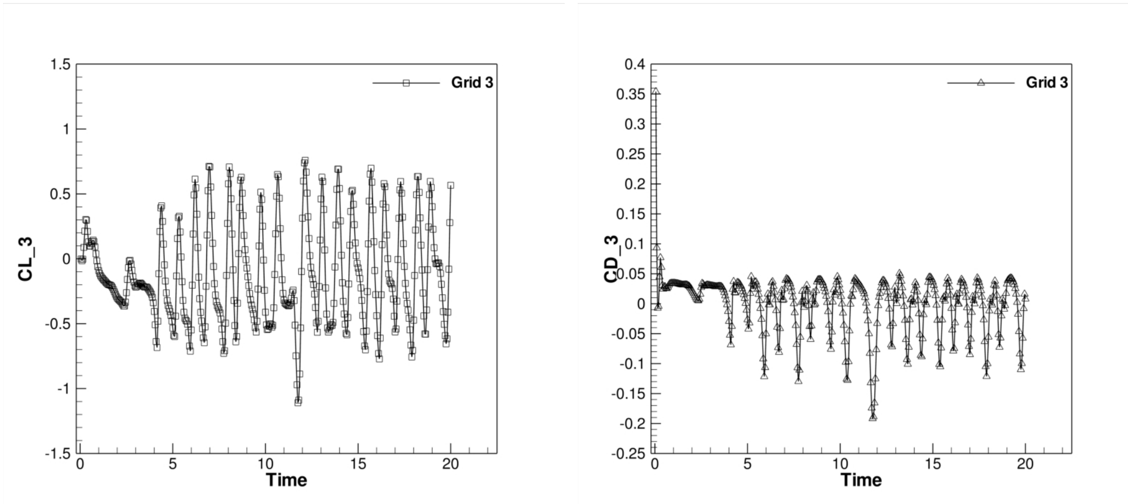
This test case considers the viscous flow over tandem NACA0012 airfoils with flow conditions $M_\infty = .2$, $Re = 10,000$, and $\alpha = 0.0^o$. Uniform mesh refinement at $p = 2$, $p = 3$ and $p = 4$ is conducted and the resulting lift and drag on the aft airfoil using the finest mesh is reported. Figures 1, 2 and 3 show lift and drag results for $p = 2$, $p = 3$ and $p = 4$ respectively.



(a) Lift vs. Time $p = 2$

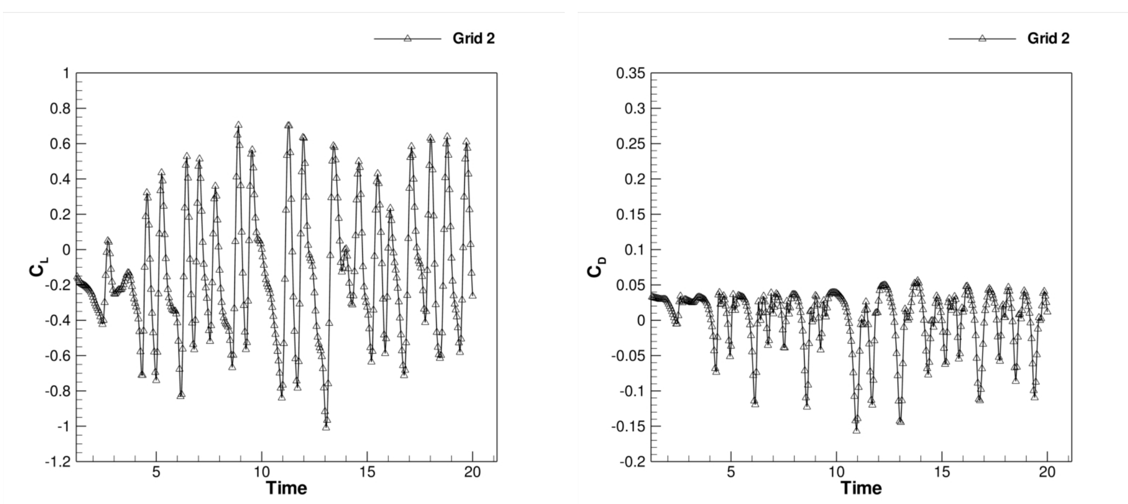
(b) Drag vs. Time $p = 2$

Figure 1: Lift and drag time histories on the aft airfoil for the viscous flow over tandem NACA0012 airfoils at $p = 2$. Initial condition A.



(a) Lift vs. Time $p = 3$ (b) Drag vs. Time $p = 3$

Figure 2: Lift and drag time histories on the aft airfoil for the viscous flow over tandem NACA0012 airfoils at $p = 3$. Initial condition A.



(a) Lift vs. Time $p = 4$ (b) Drag vs. Time $p = 4$

Figure 3: Lift and drag time histories on the aft airfoil for the viscous flow over tandem NACA0012 airfoils at $p = 4$. Initial condition A.