Planning and preparations for final project

Aytahn Ben-avi, Diogo Filipe Cravo da Costa, Tom van Aaken, Trey Gower

April 7, 2025

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1 Matrix of Simulations

Re = 266000, $\alpha = -2.5°$	Re = 189500, $\alpha = -2.5°$	Re = 135500, $\alpha = -2.5°$
Re = 266000, $\alpha = 0°$	Re = 189500, $\alpha = 0°$	Re = 135500, $\alpha = 0°$
Re = 267000, $\alpha = 2.5°$	Re = 190500, $\alpha = 2.5°$	Re = 135600, $\alpha = 2.5°$
Re = 267000, $\alpha = 5°$	Re = 189800, $\alpha = 5°$	Re = 134900, $\alpha = 5°$
Re = 267000, $\alpha = 10°$	Re = 189600, $\alpha = 10°$	Re = 135500, $\alpha = 10°$
Re = 267000, $\alpha = 12.5°$	Re = 189500, $\alpha = 12.5°$	Re = 135400, $\alpha = 12.5°$

Table 1.1: Simulation Matrix for OpenFOAM Runs

Above is the full matrix of simulations to be run for the final project. This matrix encompasses all of the combinations of Reynolds number and Angle of Attack that were tested in the wind tunnel. All of these simulations are based on "3d-wing-RAS-Spalart-Allmaras-finemesh" found in the class repository. As the name implies, this is a Reynolds Averaged Navier Stokes simulation using the single-equation Spalart-Allmaras closure. The only changes made to the files were to change the input Re and α, as well as changing the allocation and decomposition to match the nodes and queues used on Frontera.

Meshes of greater refinement were considered, but were abandoned due to concerns around simulation runtime. These are illustrated in the table below:

Description of mesh	**Cell count (with layers)**
Additional refinement region (L = 10)	139,998,880
Large cylinders at L = 10 around Leading and Trailing edges	66,829,480
Small cylinders at L = 10 around Leading and Trailing edges	46,343,378
Final chosen mesh (refined tutorial case)	22,251,746

Table 1.2: Proposed mesh cell counts

Even the least refined of our modified meshes approximately doubled the cell count. With very limited availability on Frontera, and much time lost troubleshooting strange OpenFOAM errors, the decision was made to run with the refined tutorial case, in order to keep the total simulation clock times down. Given the time constraints, simulations are to be run in priority order. The first set to be run will be the high Re cases at $\alpha = 0, 2.5, 5$. The higher Reynolds numbers are closest to the actual flow conditions over a 737, and these lower Angles of Attack have better odds of converging than higher Angles of Attack where flow separation is possible. Next, the same Angles of Attack will be run at the other two Reynolds numbers. Finally, the higher and negative Angle of Attack simulations will be run.

2 ANALYSIS OF COMPUTATIONAL COSTS

Simulation Step	Execution Time (seconds)	Wall Clock Time (seconds)
surfaceFeatures	4.22	4
snappyHexMesh	48.39	49
potentialFoam	30.45	31
simpleFoam	1131.39	1361
Total:	1214.45	1245

Table 2.1: Associated Computational Costs - Low Resolution with BL

Simulation Step	Execution Time (seconds)	Wall Clock Time (seconds)
surfaceFeatures	4.23	5
snappyHexMesh	104.97	105
potentialFoam	84.8	85
simpleFoam	3059.08	3085
Total:	3253.08	3280

Table 2.2: Associated Computational Costs - High Resolution with BL

Above are tables of the wall clock time to run each component of the base and refined tutorial cases. Given the time for the refined case, the total time required to run our full regime of simulations will be approximately 59,040 seconds, or 16.4 hours. This should be manageable, despite Frontera's limited availability.

3 COMPARISON METRICS

Simulations and experiments will be compared using the same metrics as all prior assignments, that being force and moment coefficients. These are defined as in previous assignments. Quality of simulations will be assessed by examining the final residuals of each quantity in convergence plots. Residuals that stabilized at a small value by the final timestep will be considered to have converged.