SANS Contributions to Case CR1

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SANS

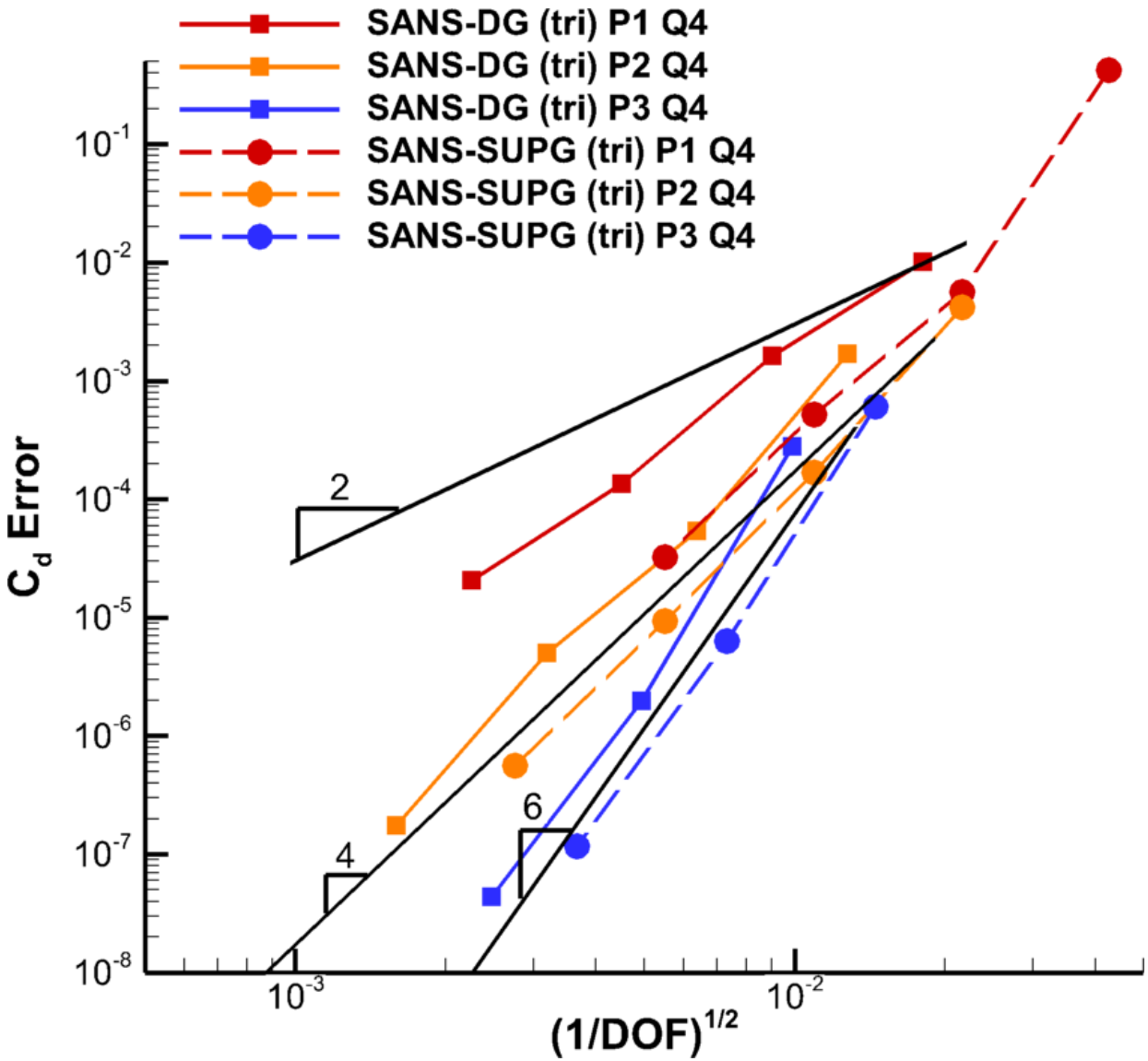
Solution Adaptive Numerical Simulator (SANS):

- PDE agnostic (advection-diffusion-reaction)
  - RANS: negative-SA
  - Automatic Differentiation
- Stabilized-CG, DG, HDG, EDG discretizations
  - DG-BR2 used here
- Linear Solvers
  - GMRES
  - UMFPACK, MKL-PARDISO, and PETSc interfaces (PETSc GMRES with ILU used here)
- Non-linear Solver
  - Newton-Raphson with line search
  - PTC and P-Sequencing used here
- Output-based mesh adaption using MOESS

  minimize estimated error in output functional

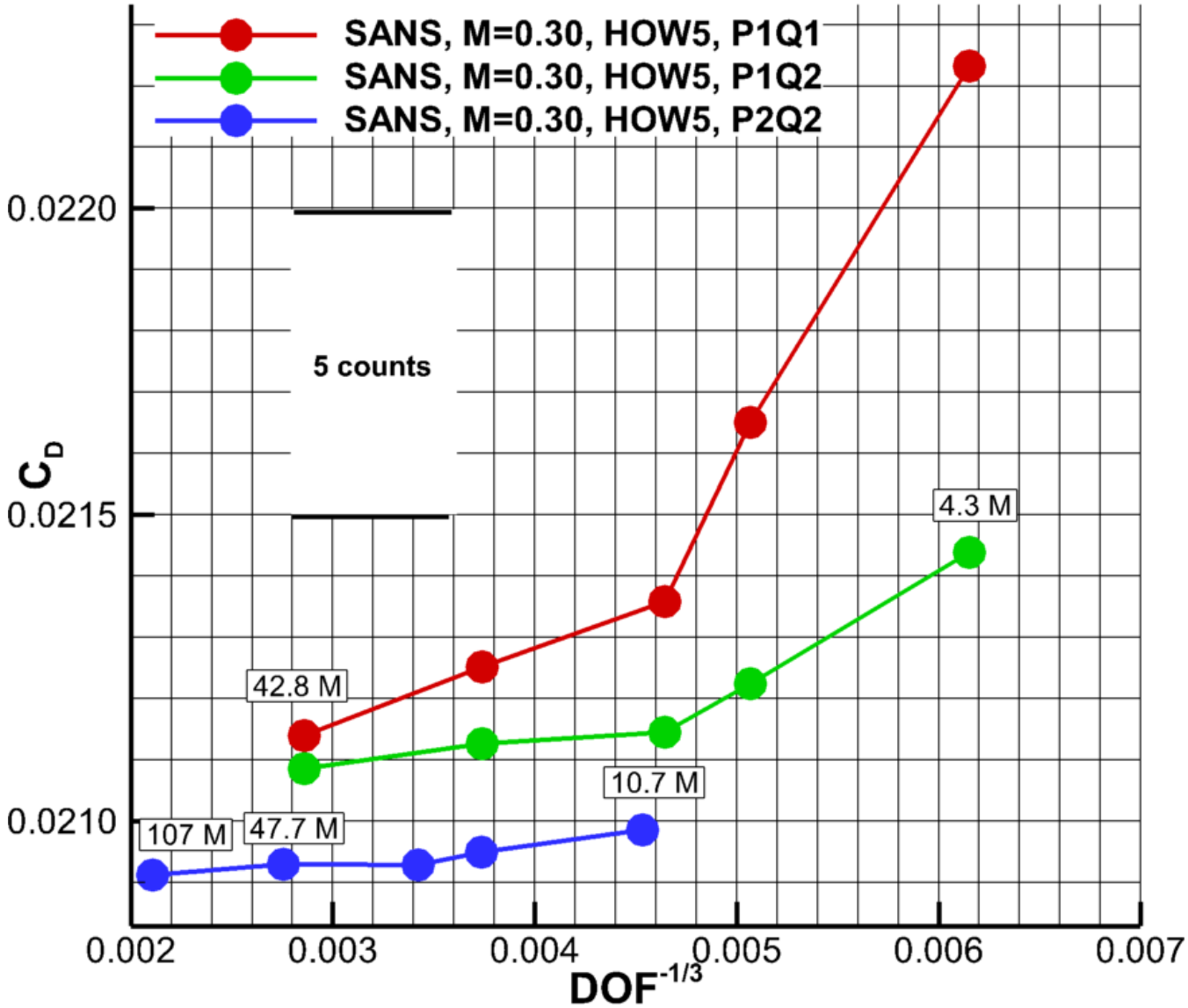
  subject to DOF count $\leq$ set cost

Joukowski Airfoil Verification



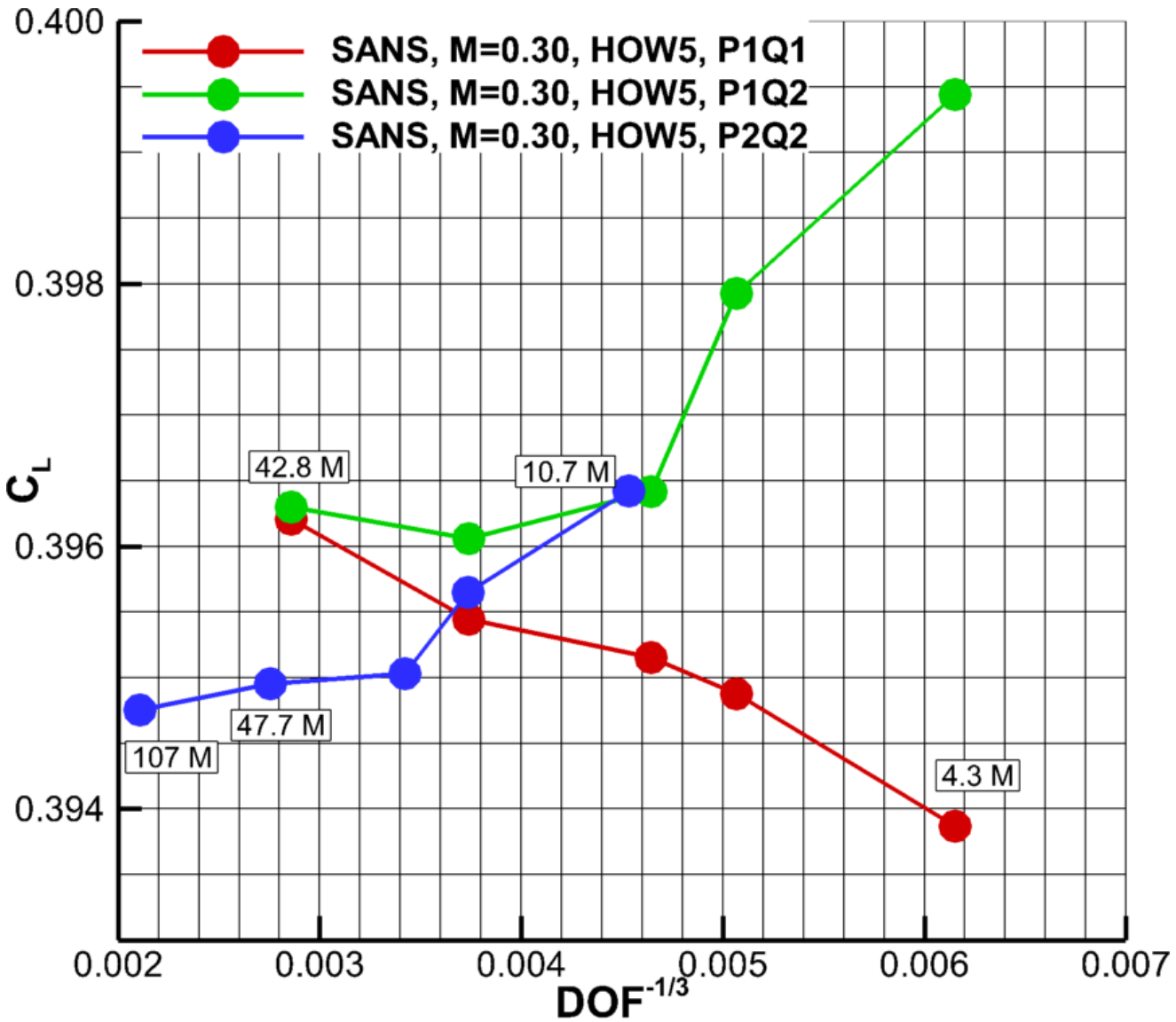
SUPG $O\left(h^{2P}\right)$, asymptotically dual consistent?

CRM High-order Workshop Meshes: C_D



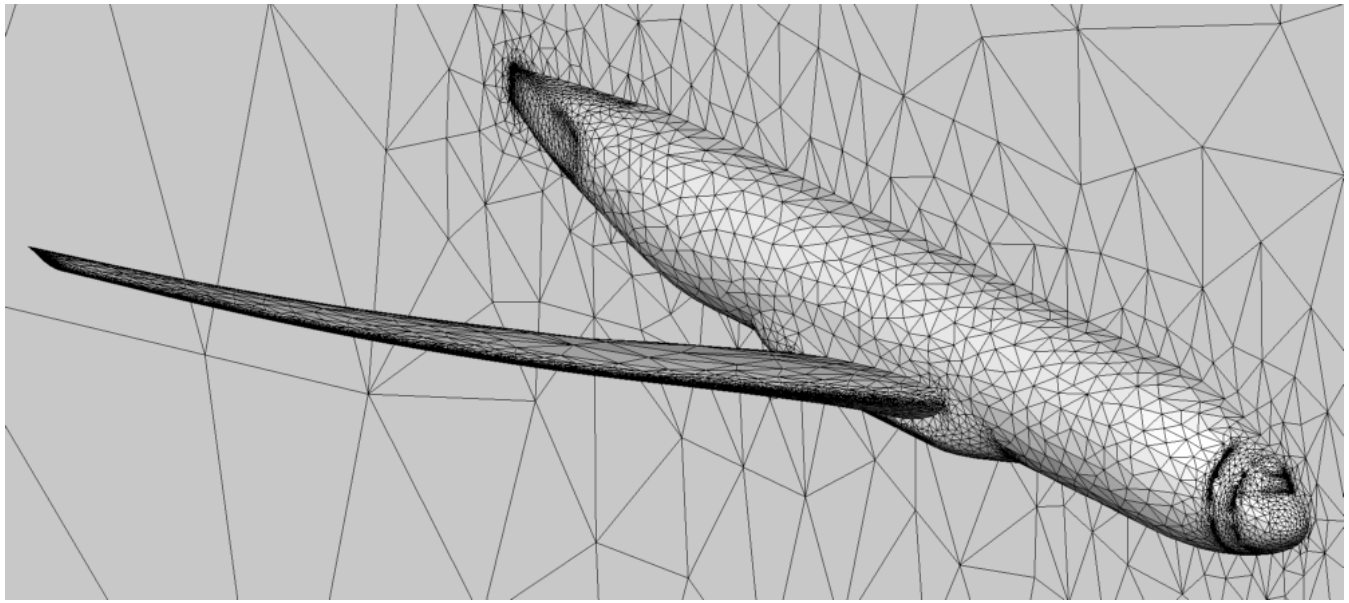
Mach=0.3. Decreased variation with increased P and Q.

CRM High-order Workshop Meshes: C_L



Mach=0.3. Relatively small variation.

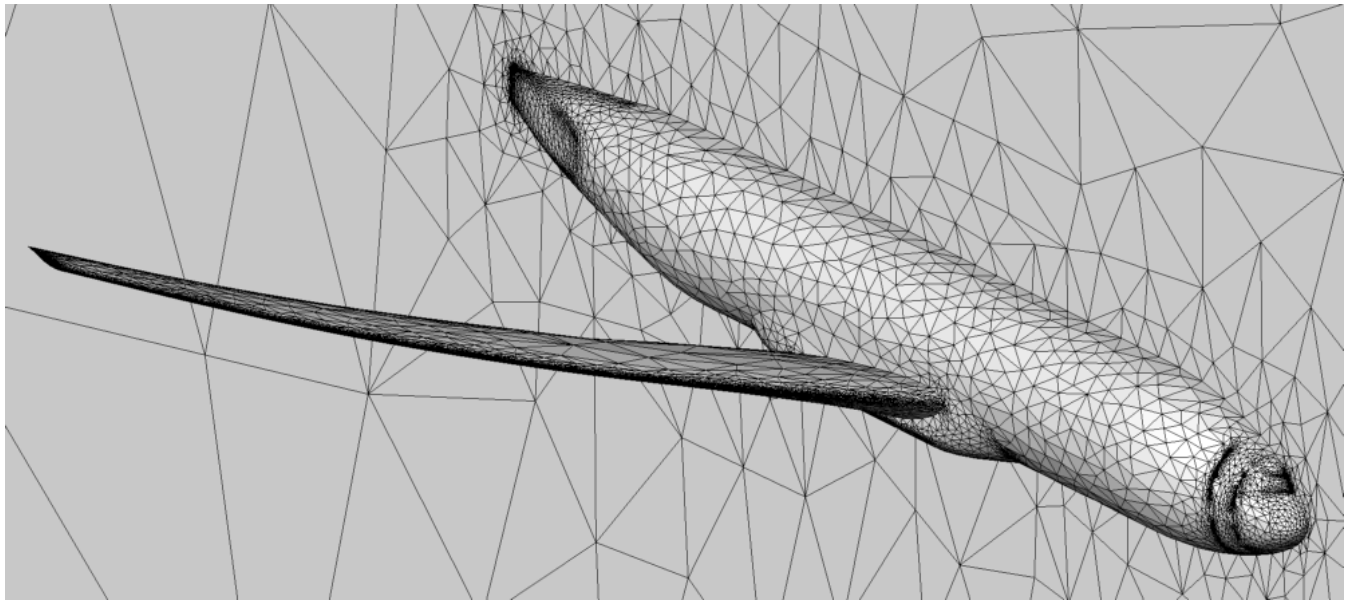
Mesh Adaptation



Initial Mesh

- Boeing metric based mesh generator EPIC
  - Curving not robust enough for adaptation
  - Poor DG $P1$ $Q1$ discretization for adaptation
- Target: 2.0M DOF (625 k elements) with drag adjoint

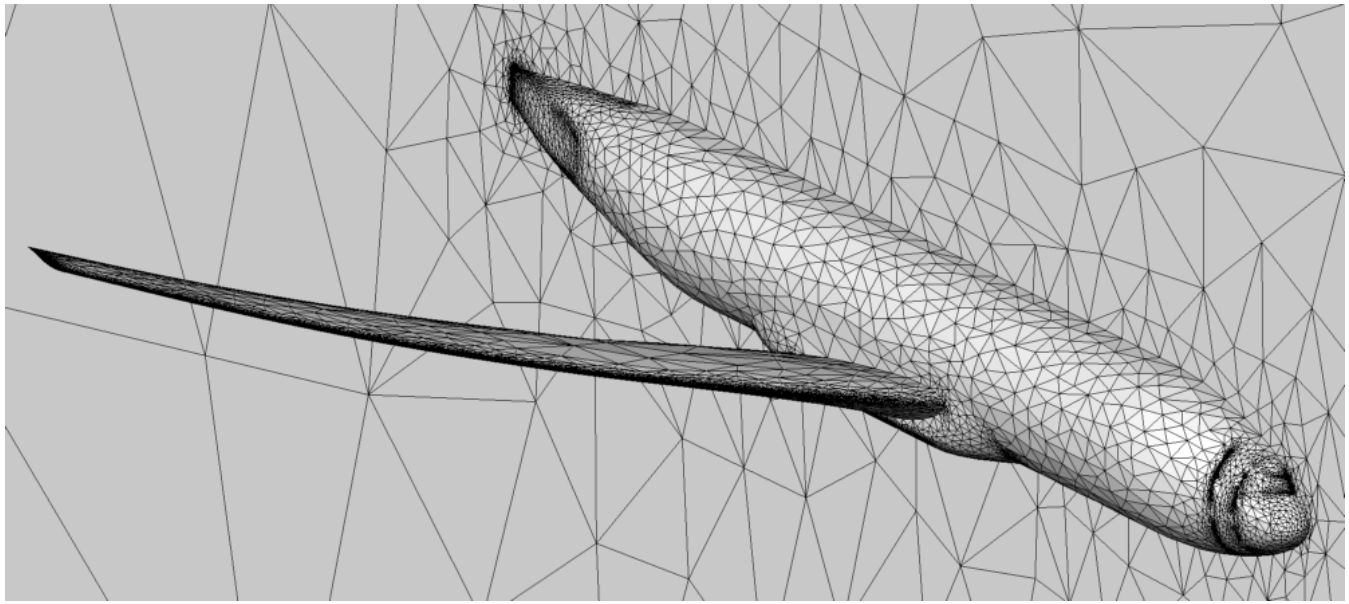
Mesh Adaptation



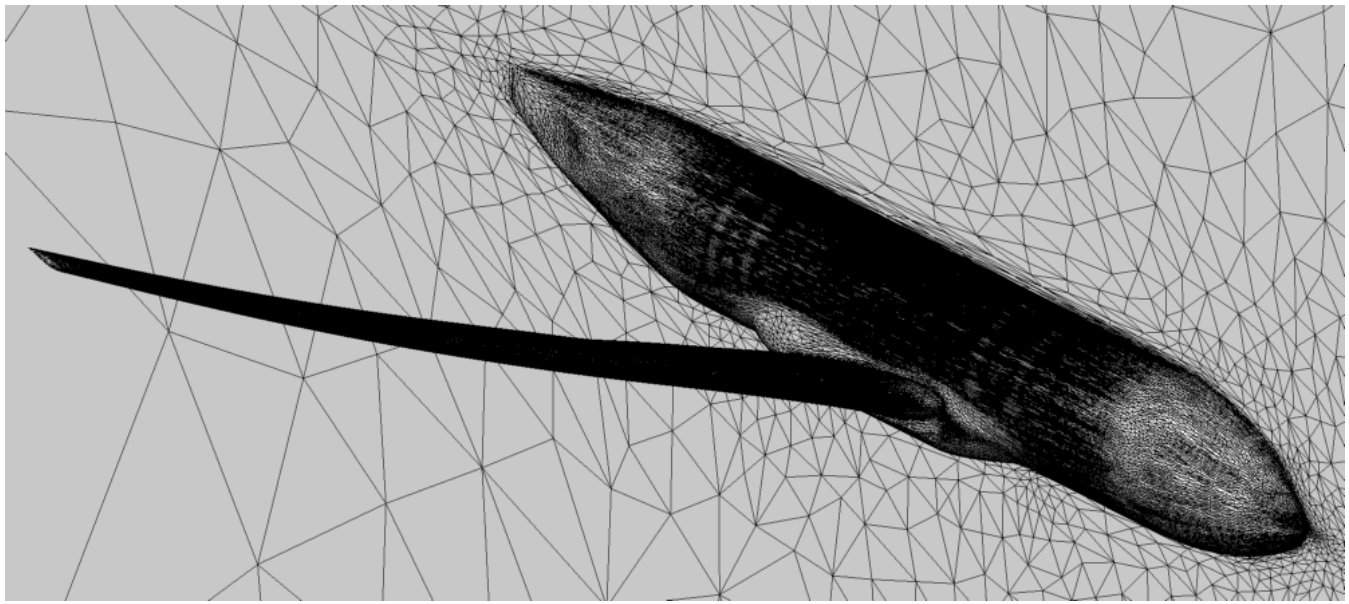
Initial Mesh

- Boeing metric based mesh generator EPIC
  - Curving not robust enough for adaptation
  - Poor DG $P1$ $Q1$ discretization for adaptation
- Target: 2.0M DOF (625 k elements) with drag adjoint
- Not enough DOF for poor $P1$ $Q1$ DG discretization
- I'm gonna need a bigger box

Adapted Mesh: Isometric View

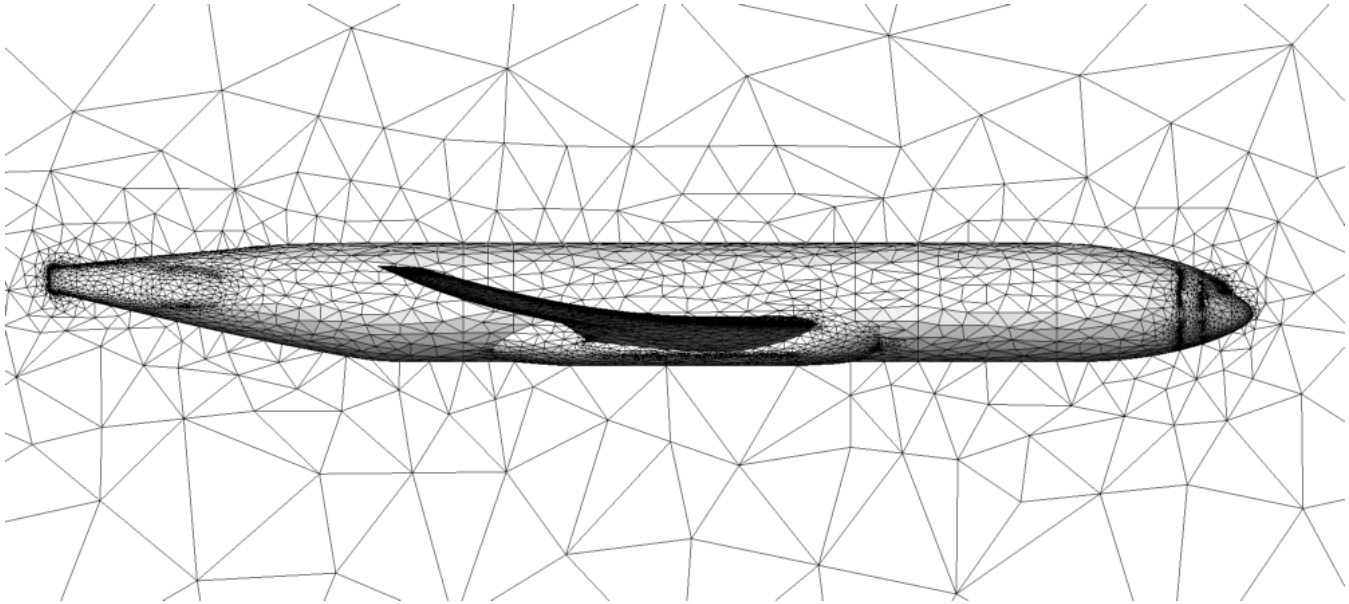


Initial
0.65M DOFs

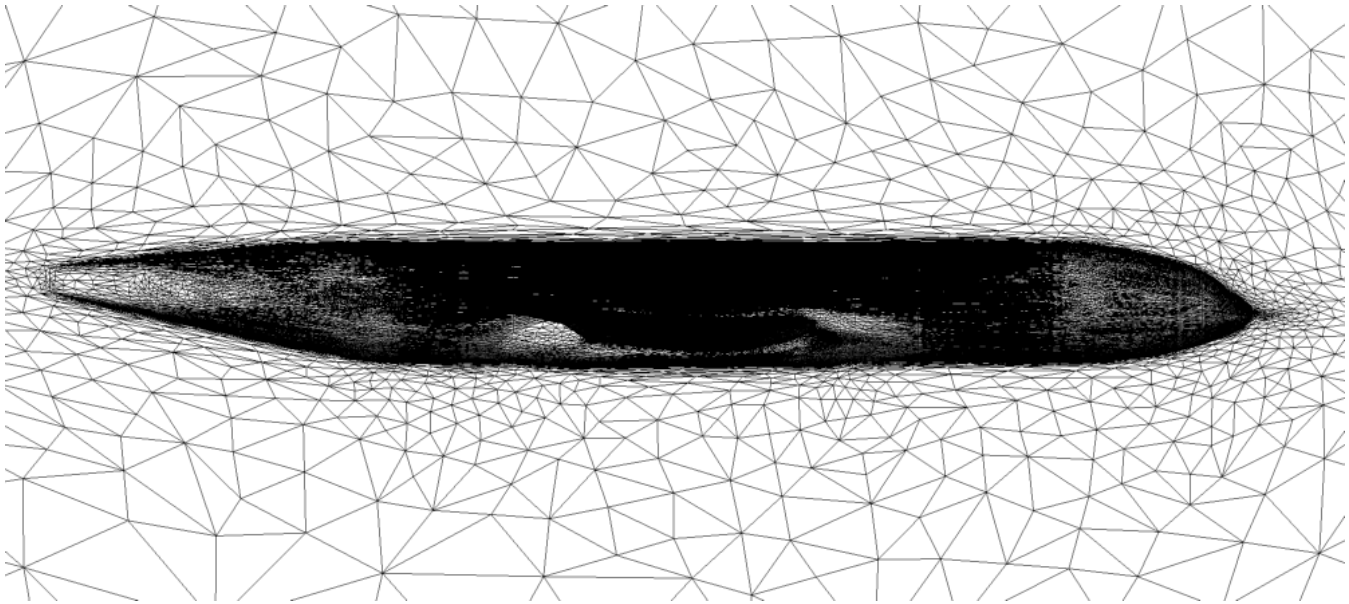


Adapted
2.3M DOFs

Adapted Mesh: Side View

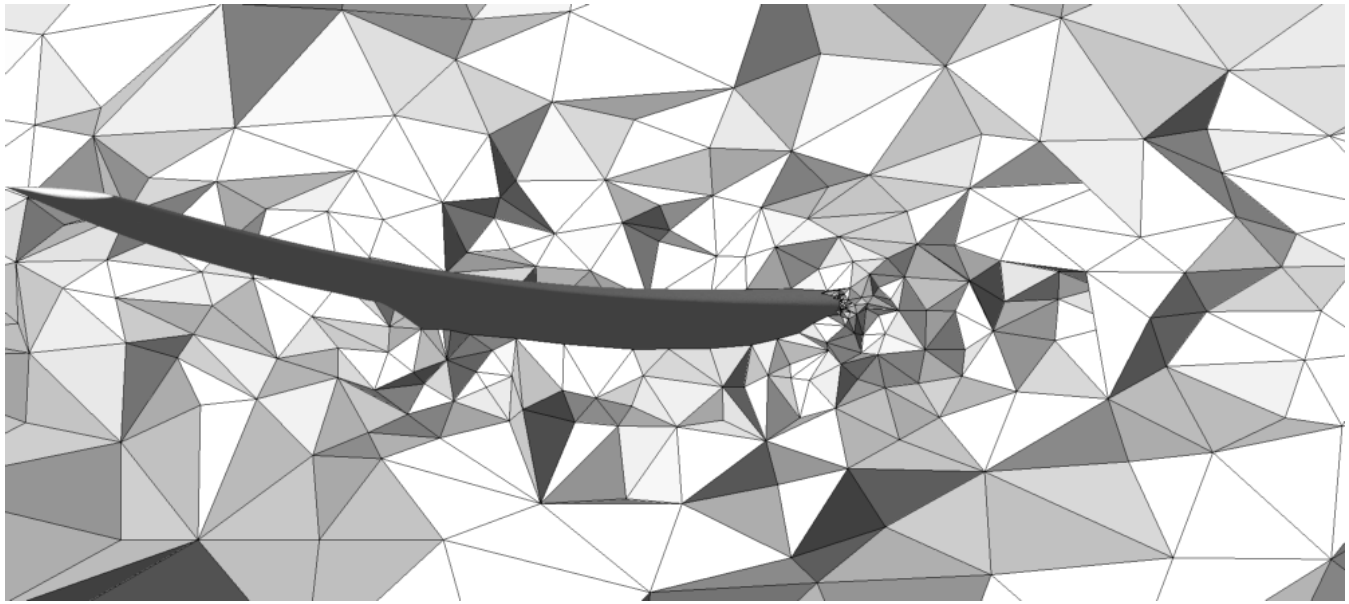


Initial
0.65M DOFs

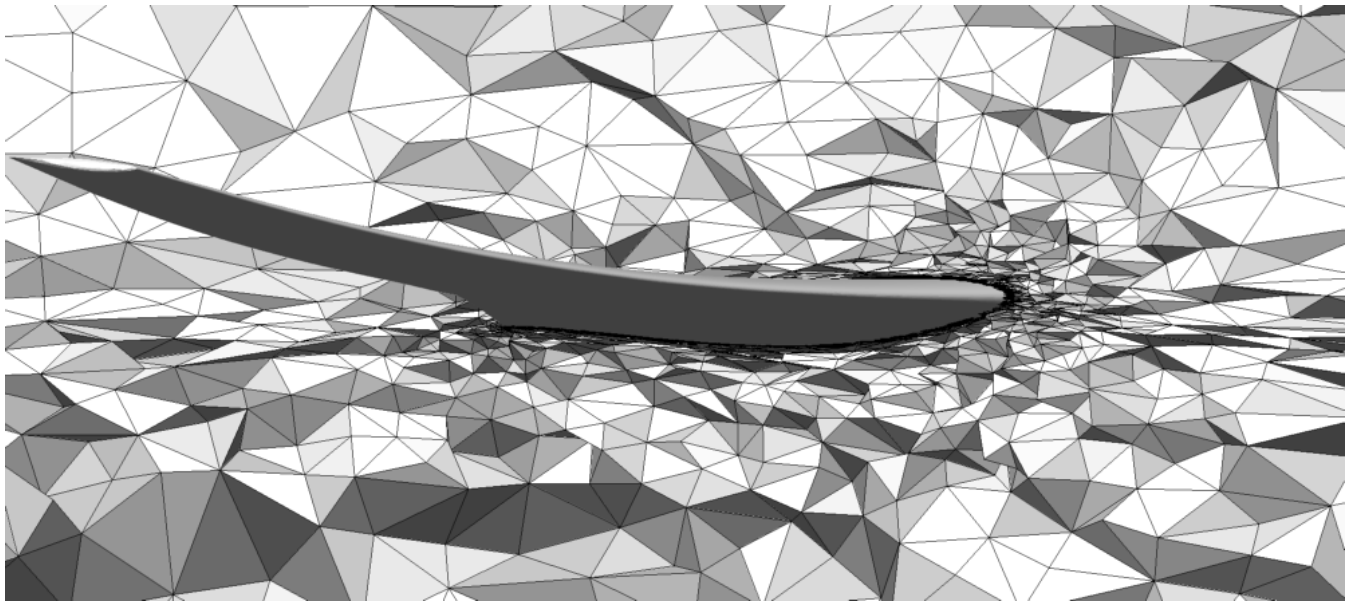


Adapted
2.3M DOFs

Adapted Mesh: Side View Crinkle Cut

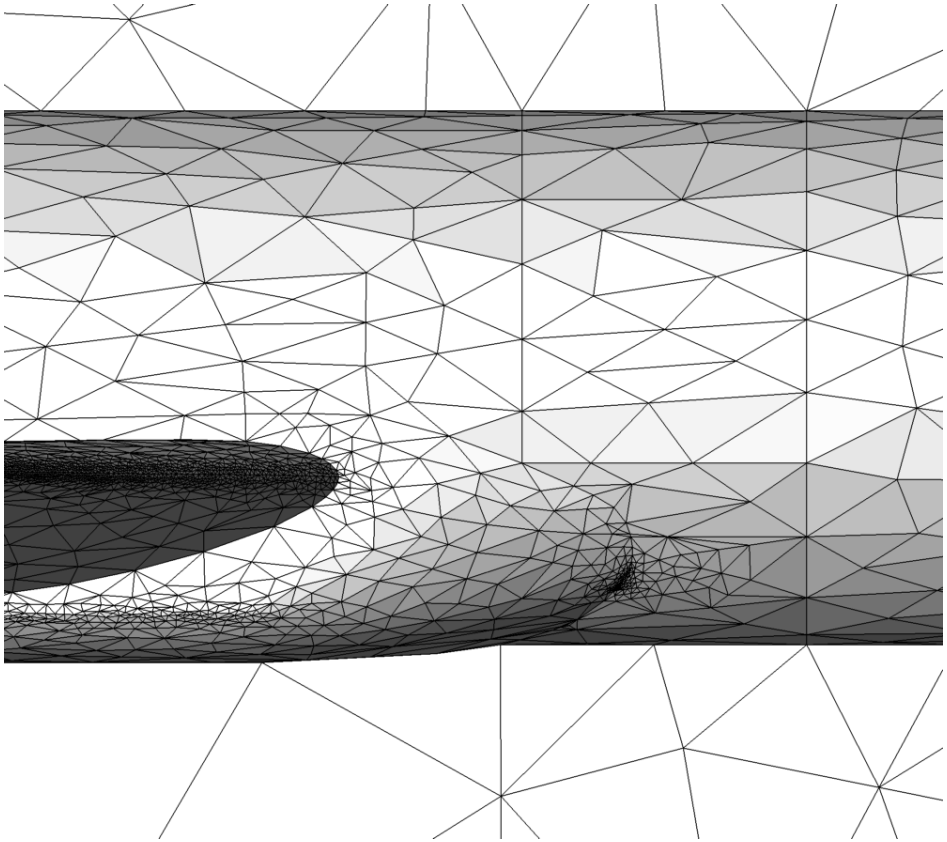


Initial
0.65M DOFs

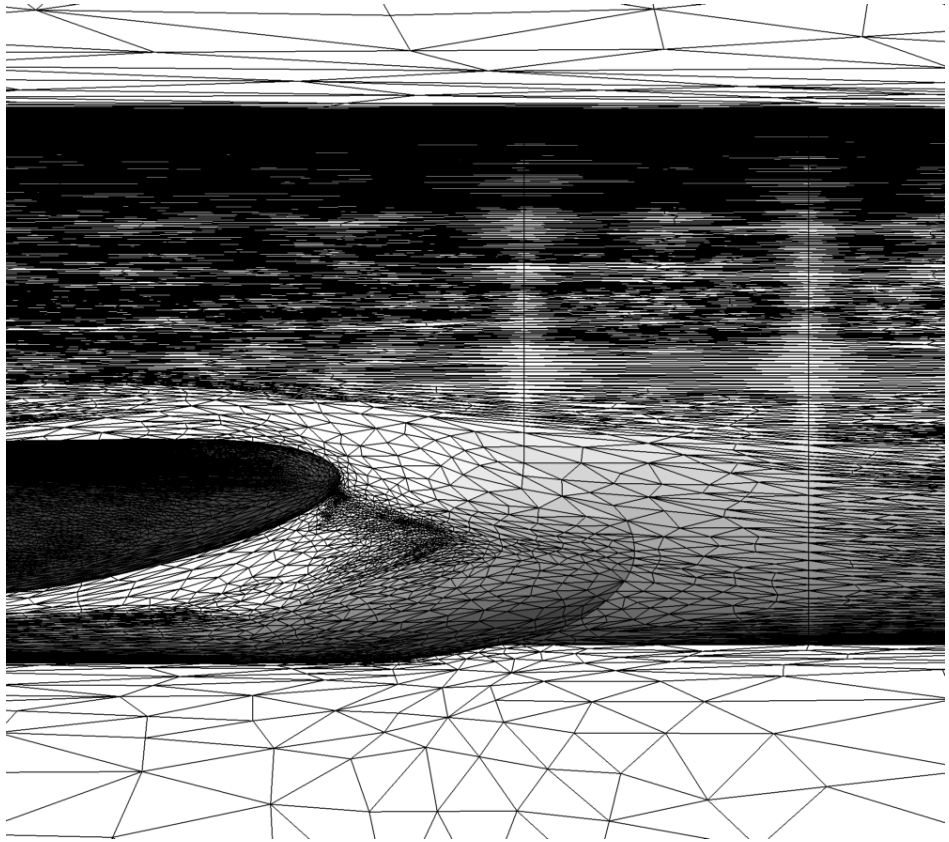


Adapted
2.3M DOFs

Adapted Mesh: Fairing Side View

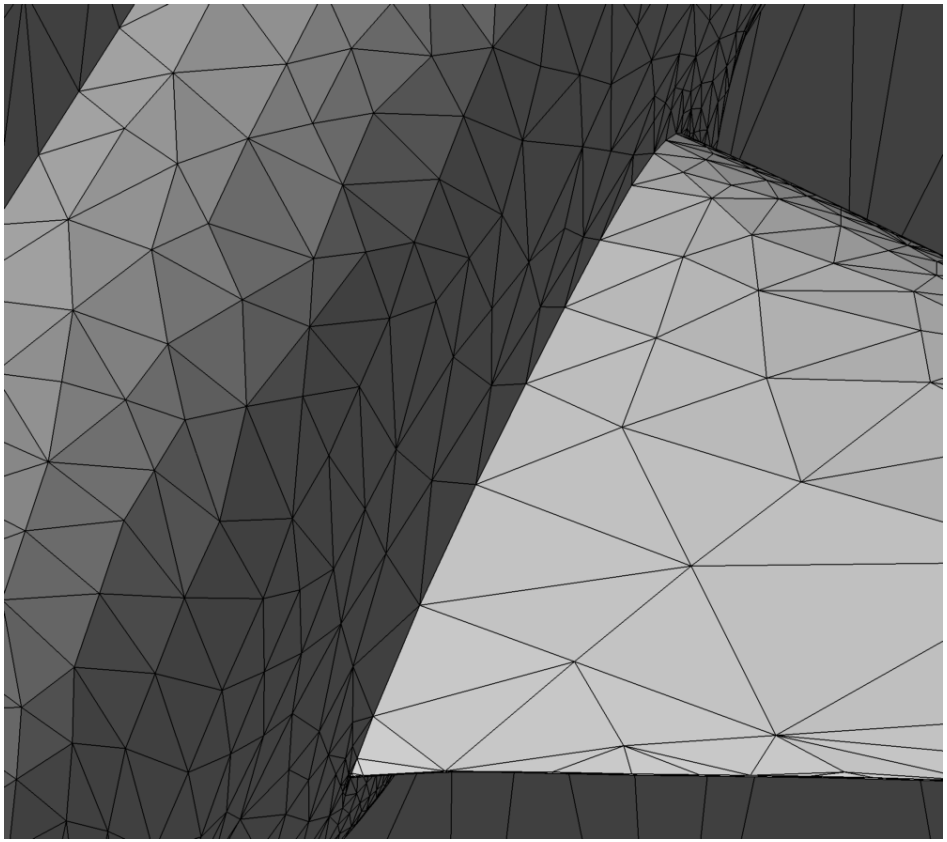


Initial, 0.65M DOFs

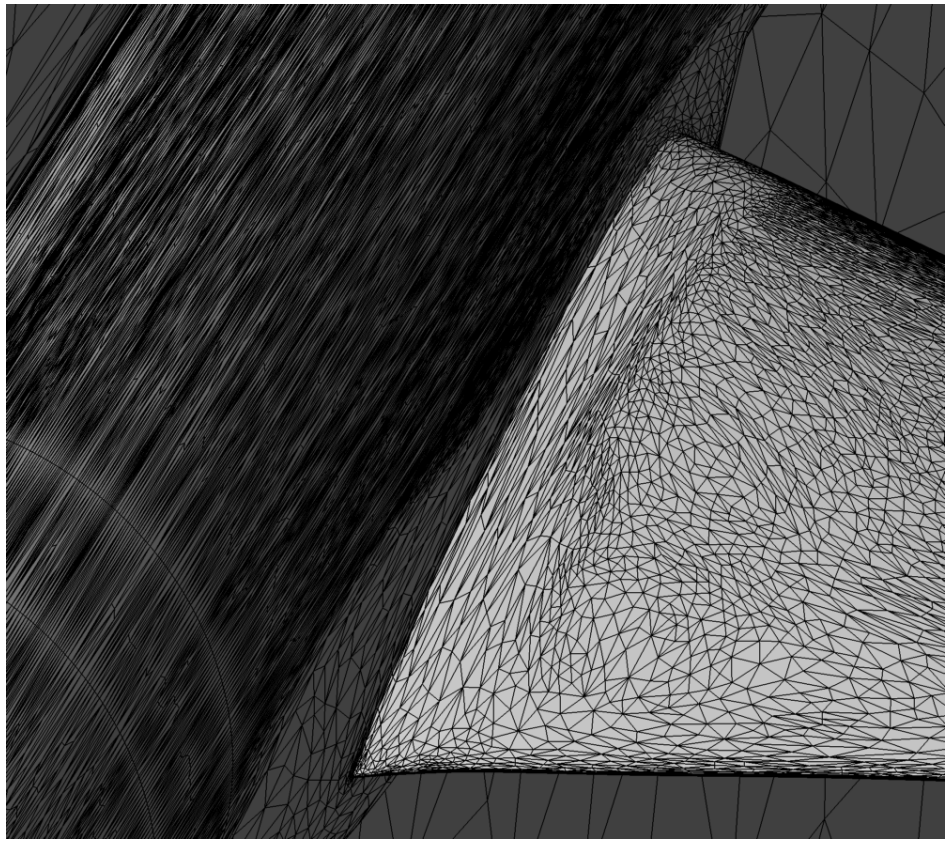


Adapted, 2.3M DOFs

Adapted Mesh: Wing Root



Initial, 0.65M DOFs



Adapted, 2.3M DOFs

Summary

- Small variation in C_D
  - For $P2$ less than 1 count across all meshes
  - How coarse can we go?
- Relatively small variation in lift
- Mesh Adaptation
  - Need robust metric conforming mesh curving
  - Poor $P1$ $Q1$ needs more DOF.
  - Lack of resolution in boundary layers.