Practice Airfoil

GenesisCFD Tutorial

CREATE™ - AV Quality Assurance
January 8, 2018

Overview

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Why This Tutorial?

Recommended Prerequisites:

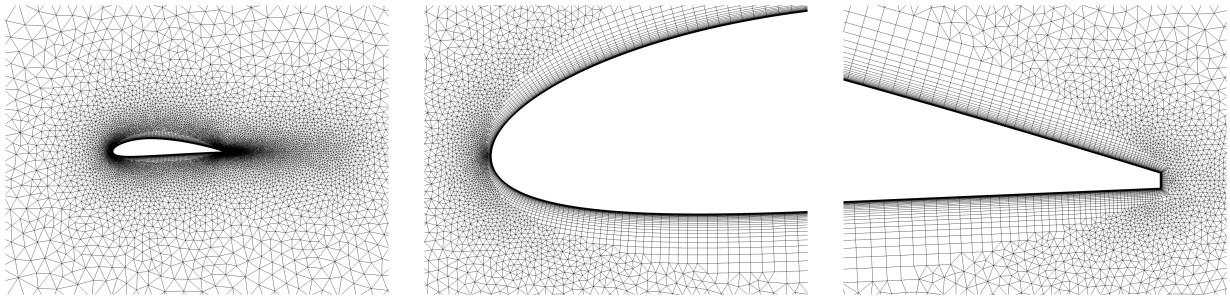
- 2D Static Aero Tutorial OR
- Some hands-on experience with GenUI/GenesisCFD

- Use Case: Low speed NACA 4415 airfoil
- Objectives:
  1. Review the basic GenesisCFD workflow - start to finish
  2. Learn how to optimize KCFD settings for steady-state and low-speed aerodynamics
  3. Internalize GenesisCFD best-practices through guided practice

Overview

Mesh Setup

- Completed mesh is provided (naca4415-mixed.avm), as well as an AVUS mesh (naca4415-mixed.grd) to practice converting and setting up your mesh
- Mixed quads/triangles (45.9k cells), wake refinement baffle aft to x=1.0c
- 400+ points around the airfoil, 8 cells across blunt trailing edge
- Leading edge is located at: (0, 0, 0)
- For more information on converting your existing meshes to the AVMesh format, see the GenesisCFD FAQ.



Mesh Setup

Open the AVUS mesh (naca4415-mixed.grd) in the Mesh Manipulation Mode of GenUI, and edit the metadata as needed. Recall that inputs with a red asterisk are required.

- In *Mesh Header*
  - Mesh Name: *Your Choice*
  - Coordinate System: *Visualize Mesh to Determine*
  - Model Scale: *1.0*
  - Grid Units: *meters (m)*
  - Reference Length/Point/Area: *leave as default and set in the XML.*
- For this simulation, no external BC file is needed. Instead, we'll assign BC types in our mesh metadata and rename the patches as well.
  - In *Patch Detail*
  - Click Patch1 to identify which edge it is by looking in the viewing window, name it and give it an appropriate bc
  - Repeat for Patch4
  - For example, rename Patch1 "farfield" and Patch4 to "airfoil" and set farfield and noslipwall BCs respectively

Save your mesh as a new AVMesh file

Simulation Details

Reference Conditions

- Mach = 0.075
- Temperature = 300 K
- Reynolds Number based on chord = 9.0e6
- Alpha 6.0^o

Geometric Quantities

- Body Moment Reference Lengths = (1.0, 1.0, 1.0)
- Body Moment Reference Point = (0.25, 0, 0)
- Body Reference Area = 1.0

Expected Results from GenesisCFD

- CLIFT = 1.08850
- CPITCH = -0.09612
- CDRAG = 0.01406

Things to Ponder: Simulation Control

1. How do we choose a time step?
2. For a simple geometry in low speed flow, do we need startup iterations?
3. For steady-state aerodynamics - how many subiterations are recommended?

Things to Ponder: Reference

1. In which unit system do we want to input our reference conditions (and other future inputs)?
2. Which reference conditions were we given? (Does *Reynolds Length* matter in this case?)
3. What if instead the flow conditions were given as:
   - Pressure: 550 kPa, Velocity: 1025.16 in/s, Temperature: 80.33 ^{o}F

Things to Ponder: Definitions

1. How are definitions, meshes, and bodies related?

2. If we want to ignore F&M on particular patches for the entire simulation, is the definitions panel the right place to do that?

Things to Ponder: Bodies

1. Is there a limit to how many bodies we can have?

2. Can multiple bodies reference the same definition?

3. If we wanted to move a body 100 units aft, 20 units down, and 50 units left, what would the *translate* vector be? (Assume xByUzL coordinate system)

Things to Ponder: Boundary Conditions

1. Are external boundary condition files used in GenesisCFD?
2. What boundary conditions cannot be set in the mesh metadata of the avm file?

Things to Ponder: Outputs

1. Can we have more than one output panel per-body?
2. Moment reference point locations are relative to what?
3. If we want to request F&M output on specific individual patches, is the outputs panel the right place to do that?
4. Where will per-patch output appear?

Things to Ponder: OutputControl

1. If we want to distinguish between pressure and viscous force contributions, how would we do that? In which tracking file will the result appear?

2. Is *Time Averaging Start Time* an iteration number or a physical time?

3. Does a *Visualization Frequency* = 0 mean: "don't output viz"?

Things to Ponder: KCFD

1. What happens if we un-check the box next to KCFD?

2. When would we change the default (SA) turbulence model?

3. Where do the KCFD default parameters come from?

Running GenesisCFD at Low Mach Numbers

By default, GenesisCFD will not converge well at low mach numbers. However, a factor of 3 or more improvement in wall clock time can be obtained by doing the following:

1. Reduce Temporal Damping by up to 1 OOM from the default
2. Monitor linear sweeps in *.cfd tracking file
3. Add sweeps if they are consistently < 12, by setting MinSweeps=12
4. If sweeps consistently at 32, raise damping slightly.

Note that these suggestions apply to both steady state and unsteady problems. For unsteady problems, the difference will be the user's choice of time step (smaller) and number of subiterations (more).

Overview

Inspect Job

1. Which command should we run in the terminal to preview the job?

Run Job

1. Sitting in your job's directory, which command should we run to submit the GenesisCFD job on your local workstation?

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1. Why This Tutorial?
2. Input Setup
   - AVMesh Conversion
   - Simulation Settings
3. Running GenesisCFD
   - Run Job
4. Results
   - Did it run?
   - Did it work?
5. What's Next?

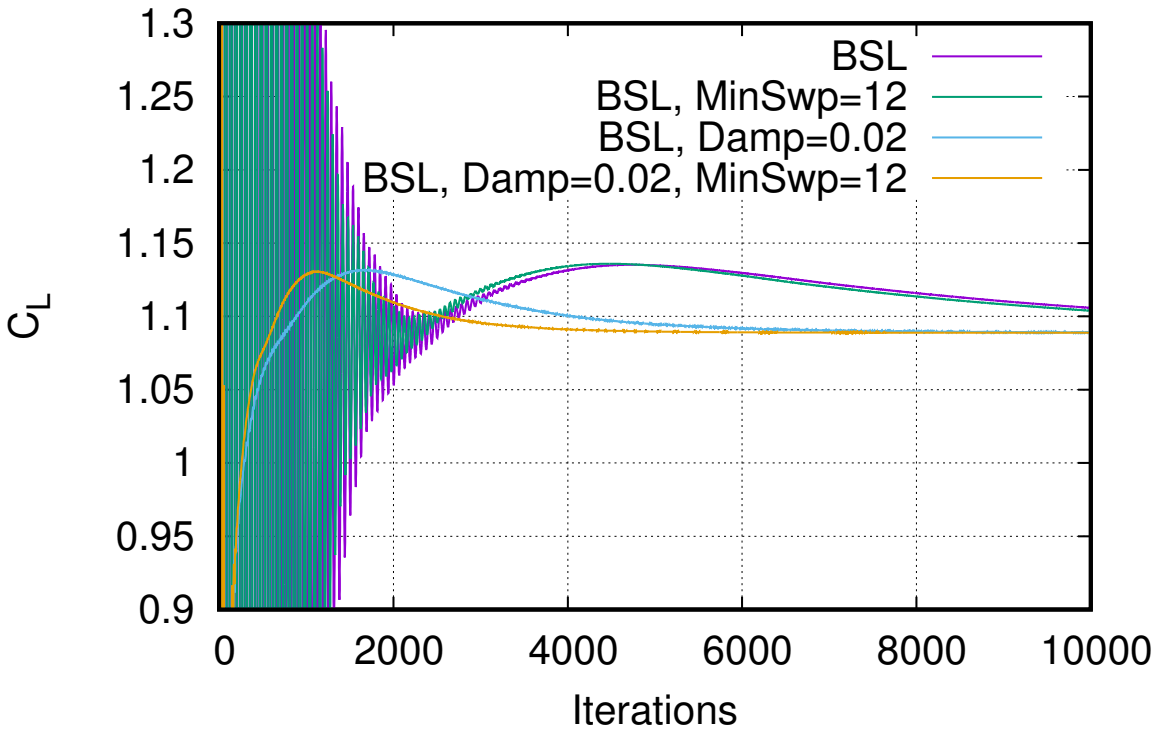
Did it run?

1. If GenesisCFD starts correctly, 4 directories will appear alongside your XML - what are they?
2. If only the *log* directory appears, where do you look for errors?
3. As the job is running, where do you look to determine the health of the solution, and look for any warnings/errors?

Cases Run

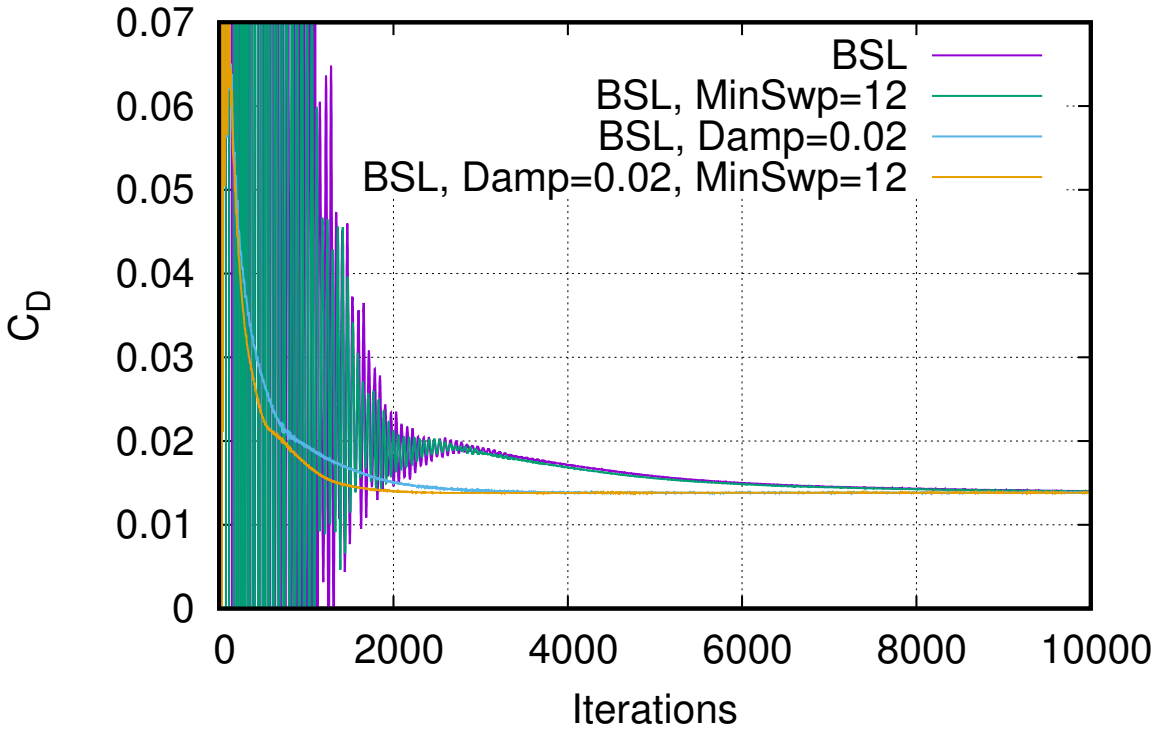
1. Baseline (BSL):
   - Turbulence Model = SA (default)
   - Damping = 0.1 (default)
   - Subiterations = 1 (recommended for steady state)
   - Time Step = 0.002 sec or L/(20*U)

Lift vs Iteration



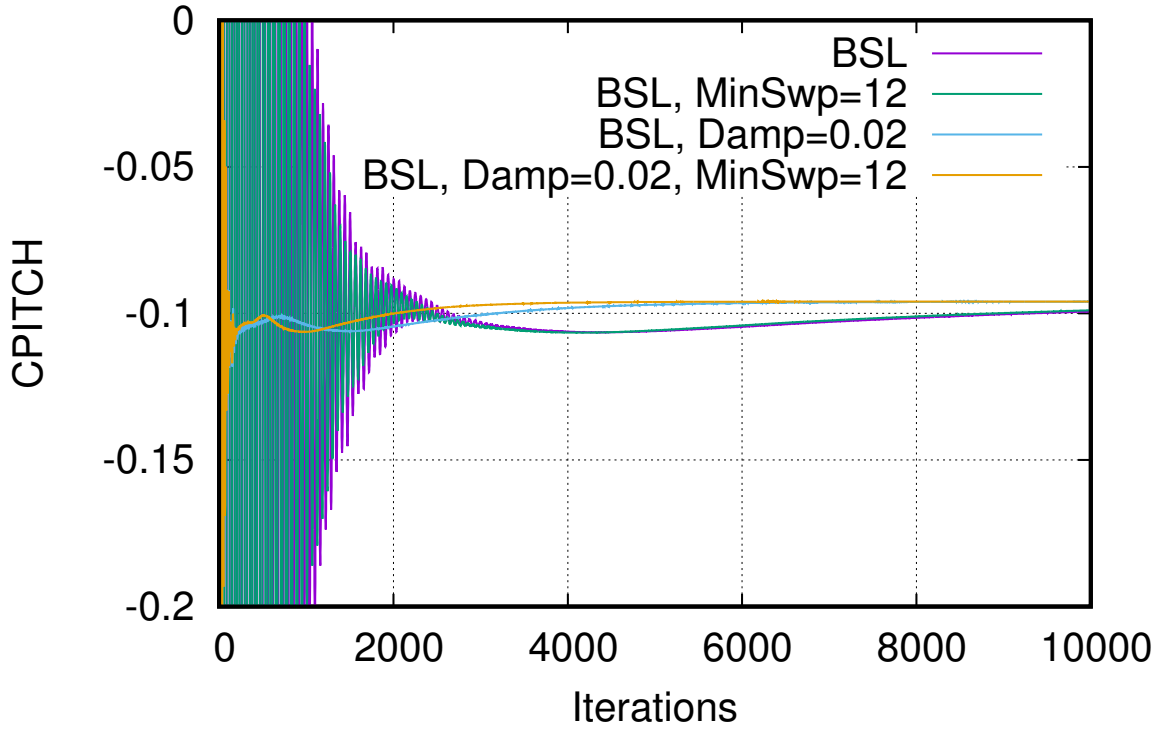
Expected Value: 1.0889

Drag vs Iteration



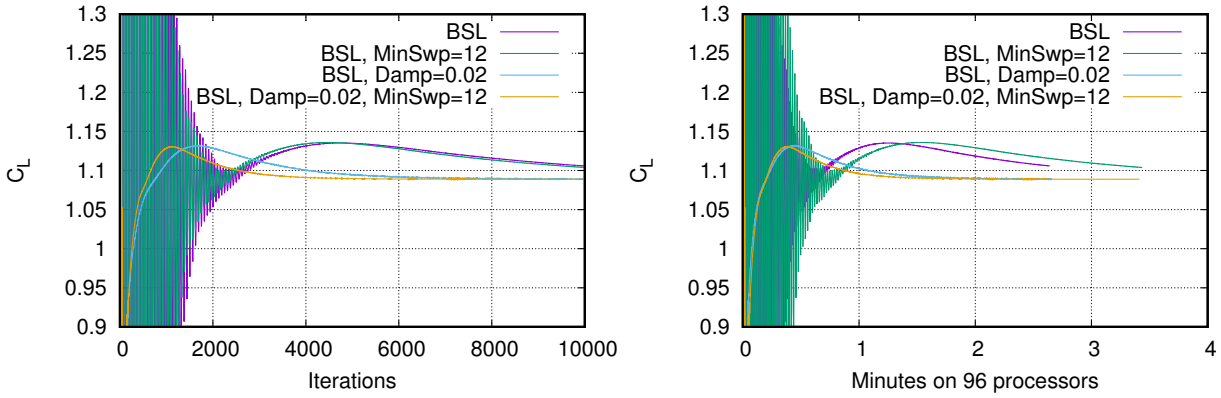
Expected Value: 0.0138

Pitching Moment vs Iteration



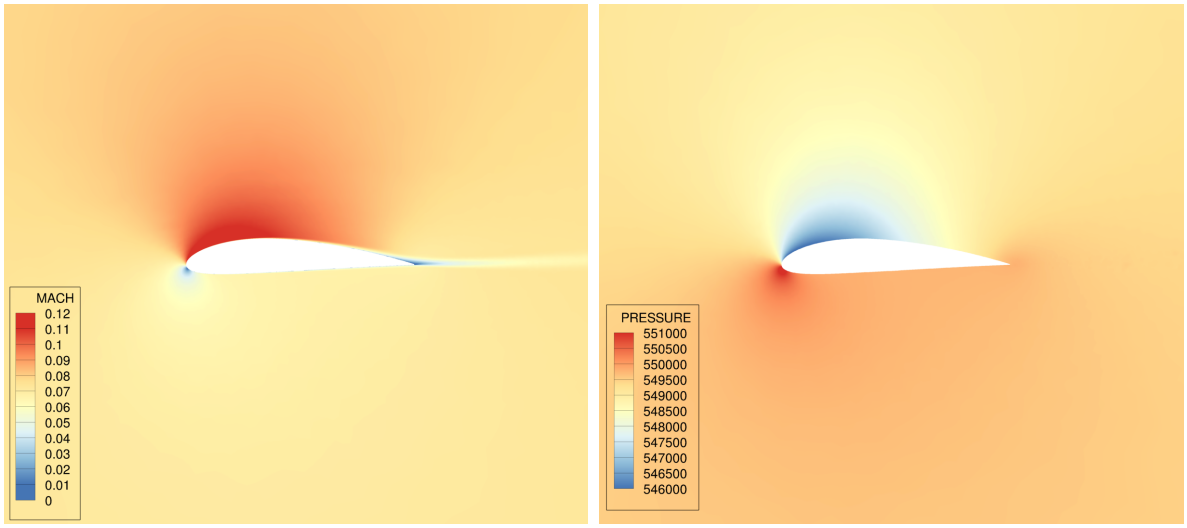
Expected Value: -0.0960

Impact on Wall Clock Time



- Simply adding more sweeps to a case with default damping is a waste of time (hence why the default allows the sweeps to drop down to the minimum of 4).
- Additional sweeps for a low-damping case do useful work in converging the linear problem, thus helping convergence.
- The "Optimal" settings (yellow line), were about 30% more expensive per iteration, but required less than 1/6th the number of iterations of the baseline case. This led to approximately a **4.5x speedup** in time to convergence.

Flow Field



(a) Mach (b) Pressure (Pa)

GenesisCFD Flow Field

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Other Possibilities

Congratulations! You've finished the practice airfoil tutorial!

Check out our other tutorials:

- GenesisCFD Frequently Asked Questions
- Capability Specific:
  - Aeroelasticity
  - Prescribed Motion
  - And many more!!!

Thanks!

If you need to ask a question, request a feature, or report a bug, please contact CREATE-AV Support team using the online form: HERE.