CFD Modeling of NASA's ARES Platform

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Computational Fluid Dynamics

* Cheaper and less time consuming than building models and testing in wind-tunnels.

* Processing speeds are allowing for more intense computations

* More flexibility in testing, e.g. Mars

FELISA Grid Generation for ARES

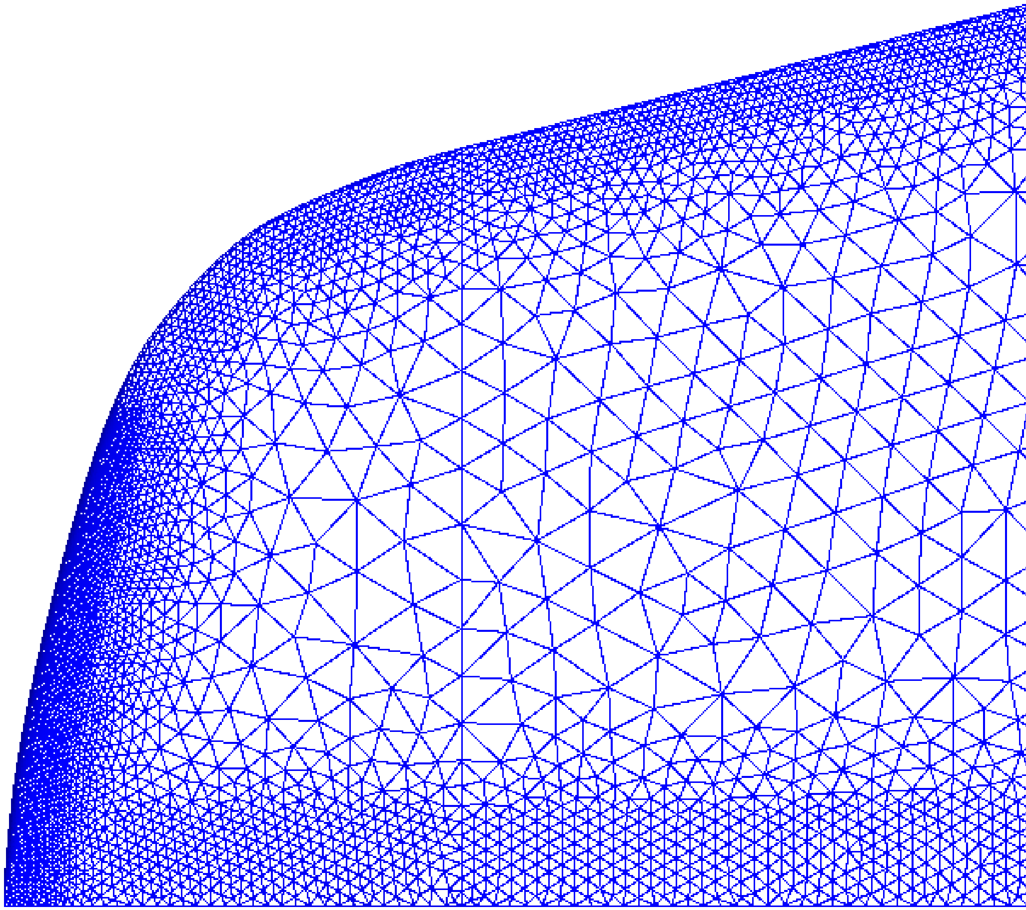
Files needed:

.con

.bco

.bac

.sur



The Solver

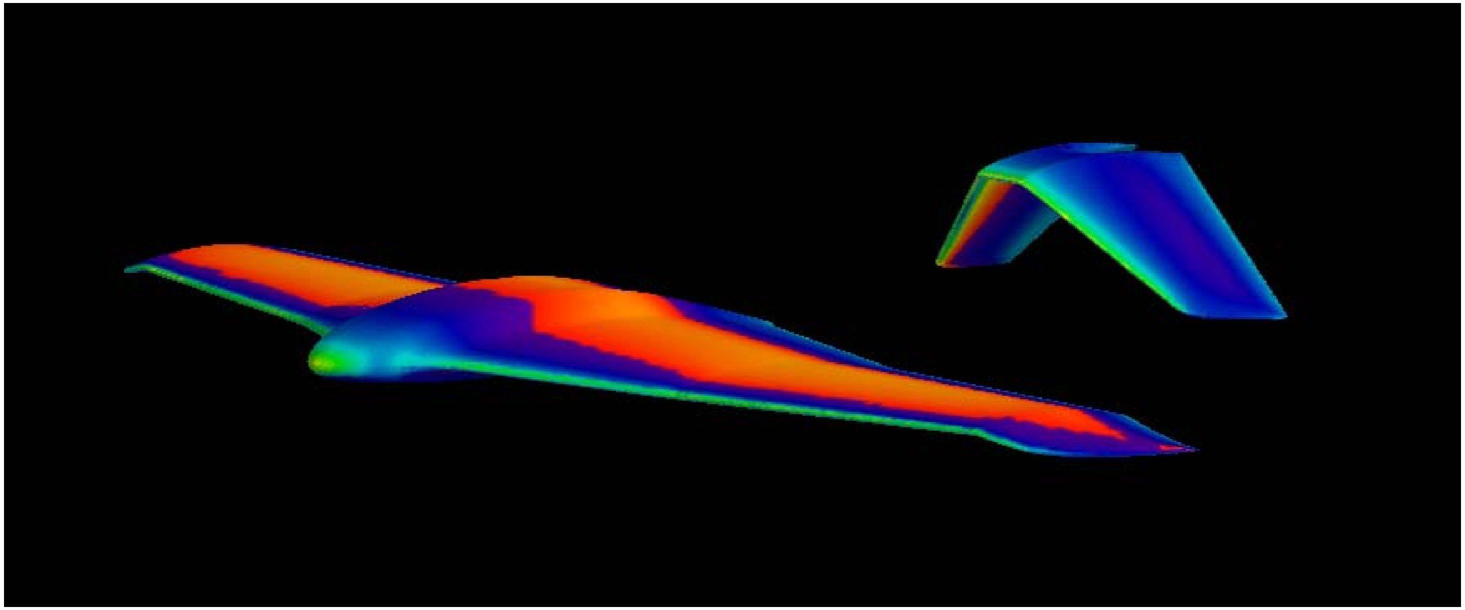
Euler3d is an modified fluid flow solver designed towards handling non-inertial problems.

The output is in the form of a loads file containing the iteration number, time step, forces and moments.

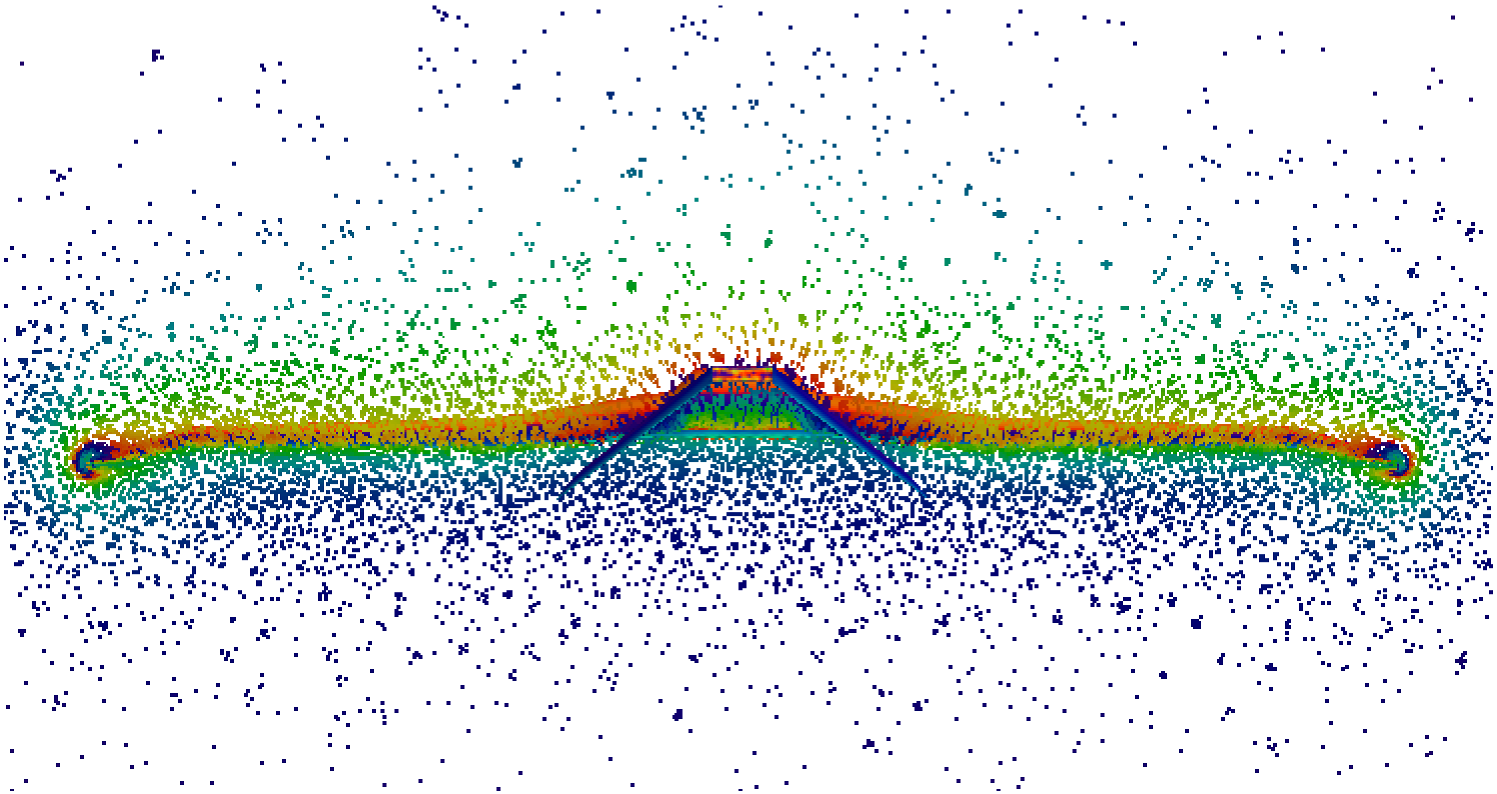
The loads file does iterations until it converges on a set of forces and moments.

4996	5.00E+02	8.80E-02	-3.64E-03	2.20E+00	-7.33E-03	-2.93E+00	-1.48E-02
4997	5.00E+02	8.80E-02	-3.64E-03	2.20E+00	-7.33E-03	-2.93E+00	-1.48E-02
4998	5.00E+02	8.81E-02	-3.64E-03	2.20E+00	-7.33E-03	-2.93E+00	-1.48E-02
4999	5.00E+02	8.82E-02	-3.64E-03	2.20E+00	-7.32E-03	-2.93E+00	-1.48E-02
5000	5.00E+02	8.82E-02	-3.64E-03	2.20E+00	-7.32E-03	-2.93E+00	-1.48E-02

Now that we have these numbers we can view the flow governed by the parameters set in the controls file over ARES in the glplot3d program...



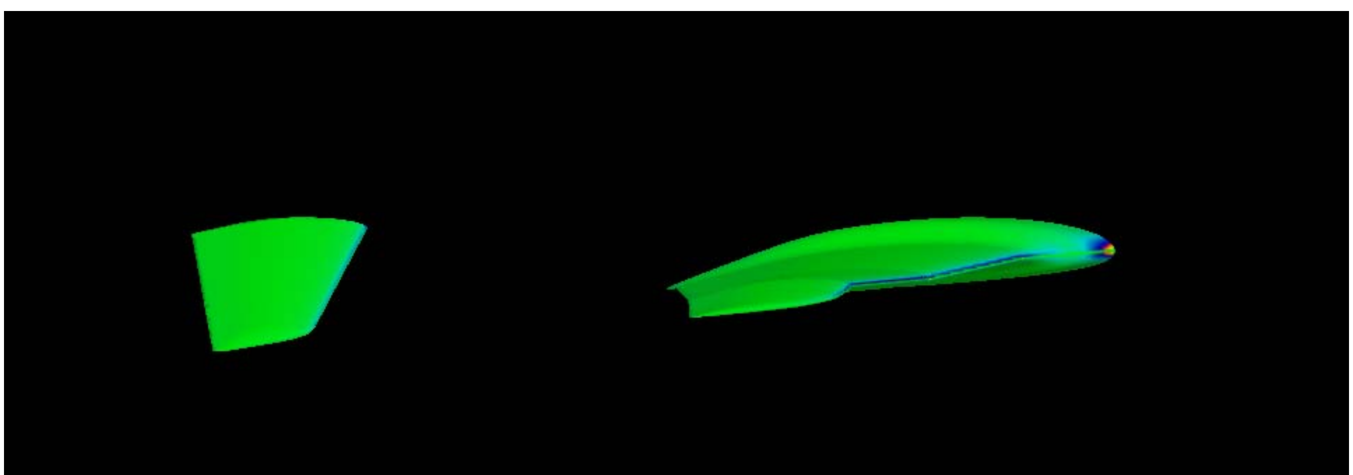
A velocity vectors cut showing vortices behind the wingtips...



The output can also be used to find the C_L, C_D or the pitching moment around the center of gravity at different angles of attack.

$$C_L = \frac{\text{Lift}}{(\frac{1}{2}\rho v^2 S)} \qquad C_D = \frac{\text{Drag}}{(\frac{1}{2}\rho v^2 S)}$$

$$M = \frac{1}{2}\rho v^2 S c C_M \qquad \text{Dynamic Pressure} = \frac{1}{2}\rho v^2$$

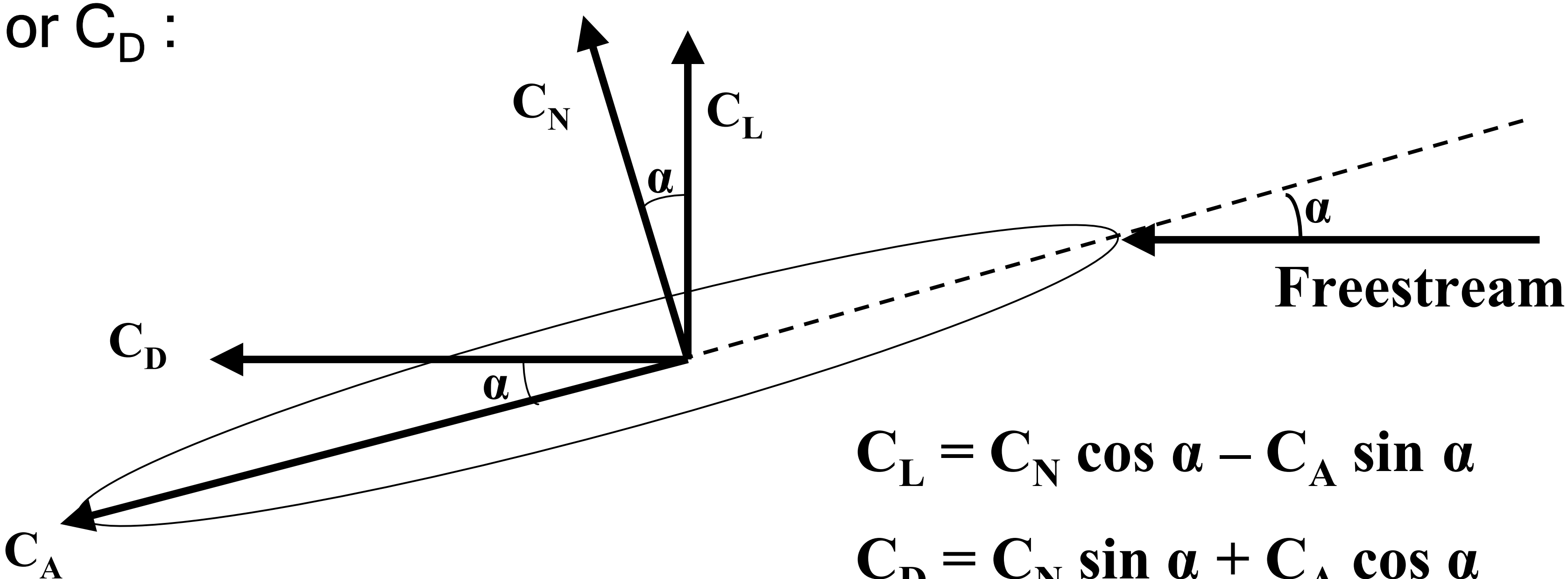


To arrive at the C_L or C_D, the force coefficients are taken from the last iteration in the loads file:

5000	5.00E+02	8.82E-02	-3.64E-03	2.20E+00	-7.32E-03	-2.93E+00	-1.48E-02

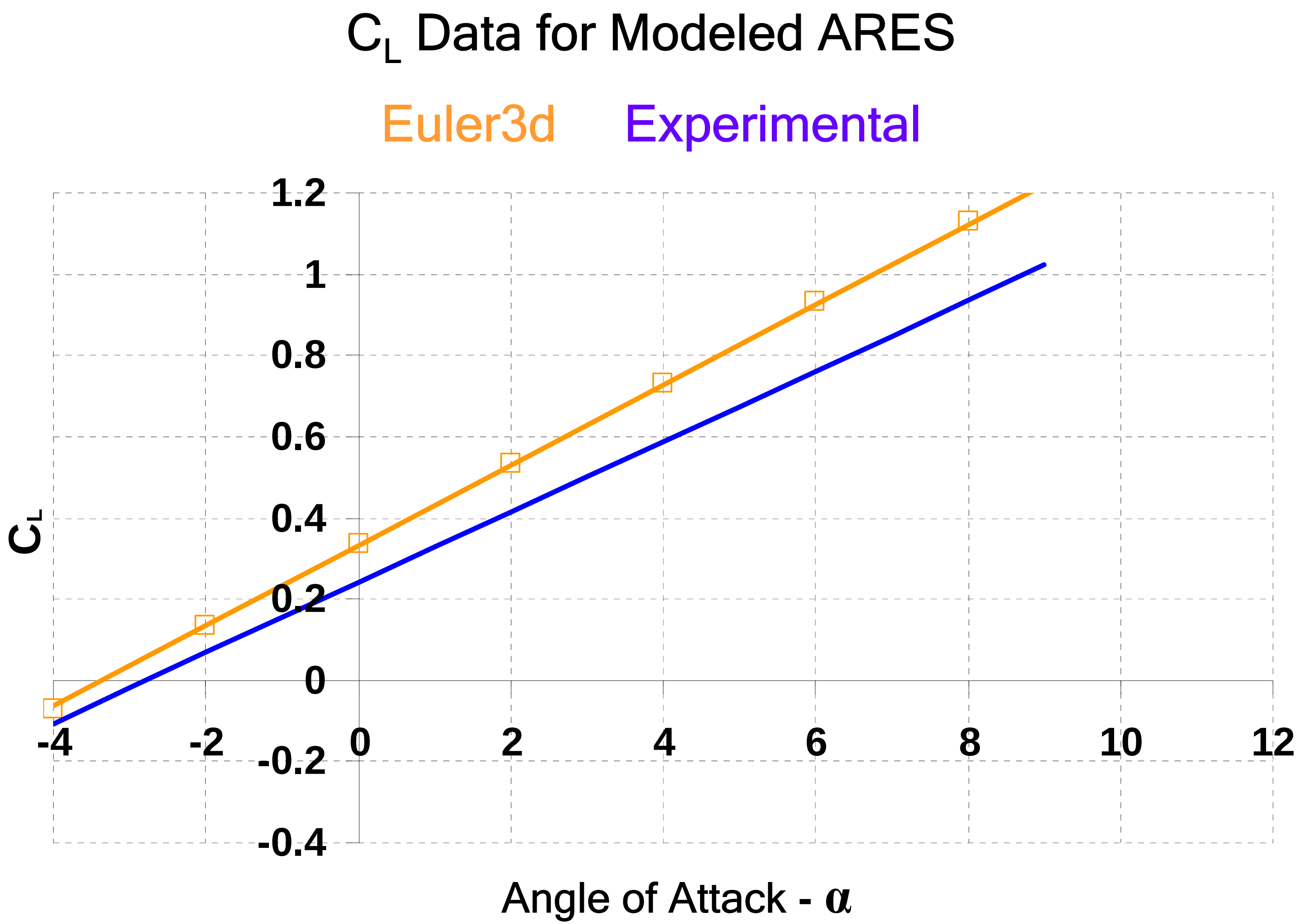
Planform Area (6.55 m²)

The forces, axial in the x direction and normal in the z direction, then go through some trigonometry to become C_L or C_D :

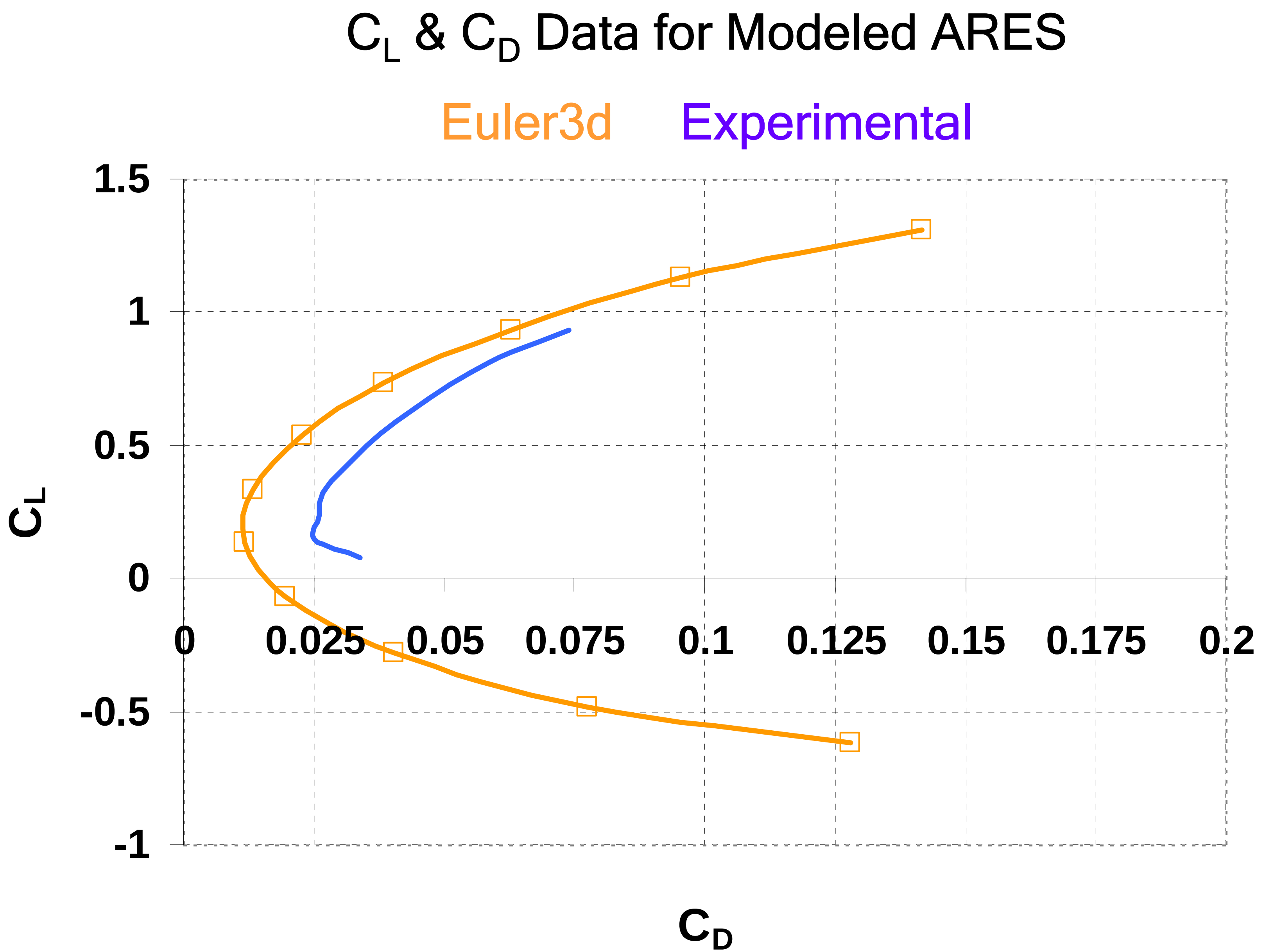


$$C_L = C_N \cos \alpha - C_A \sin \alpha$$

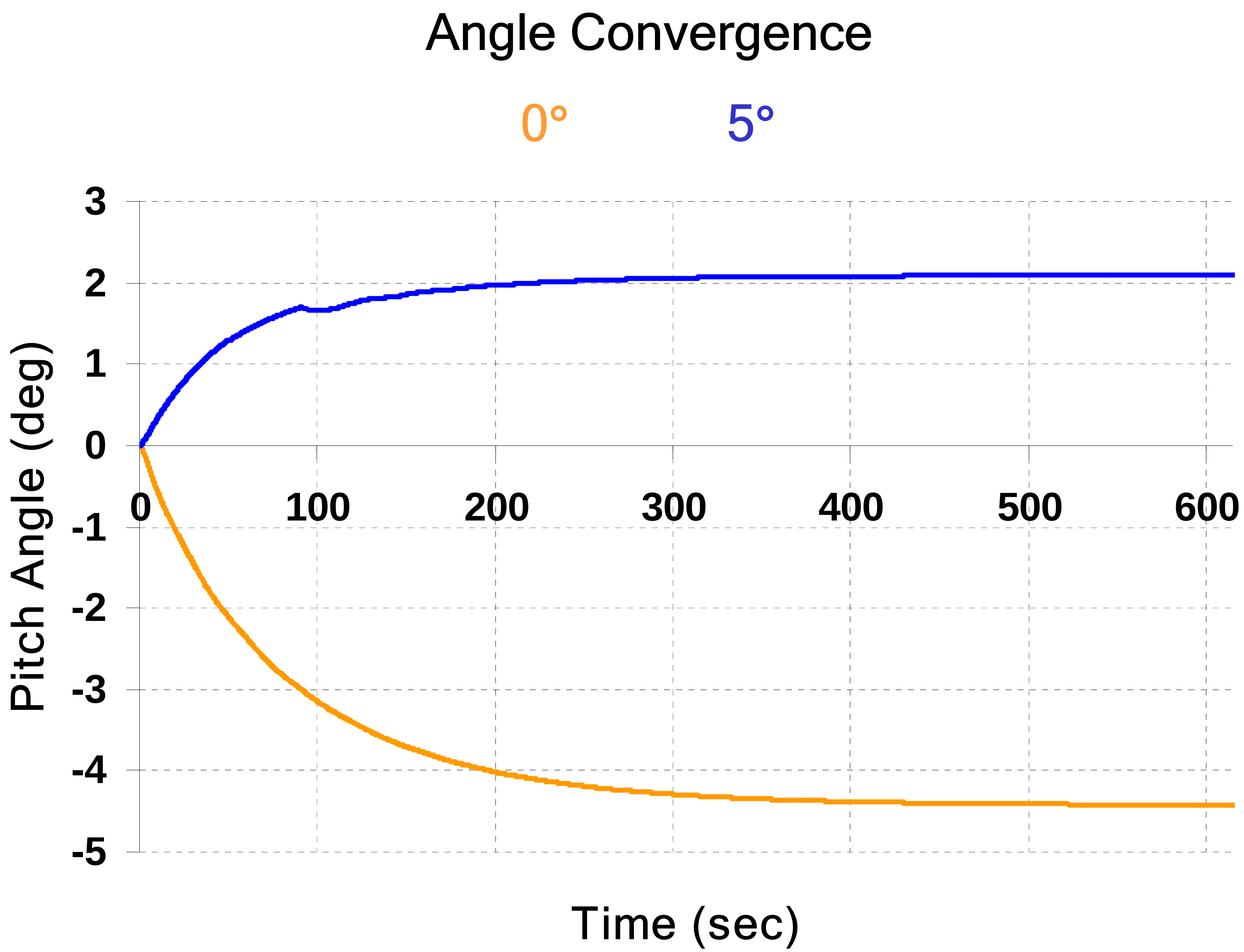
$$C_D = C_N \sin \alpha + C_A \cos \alpha$$



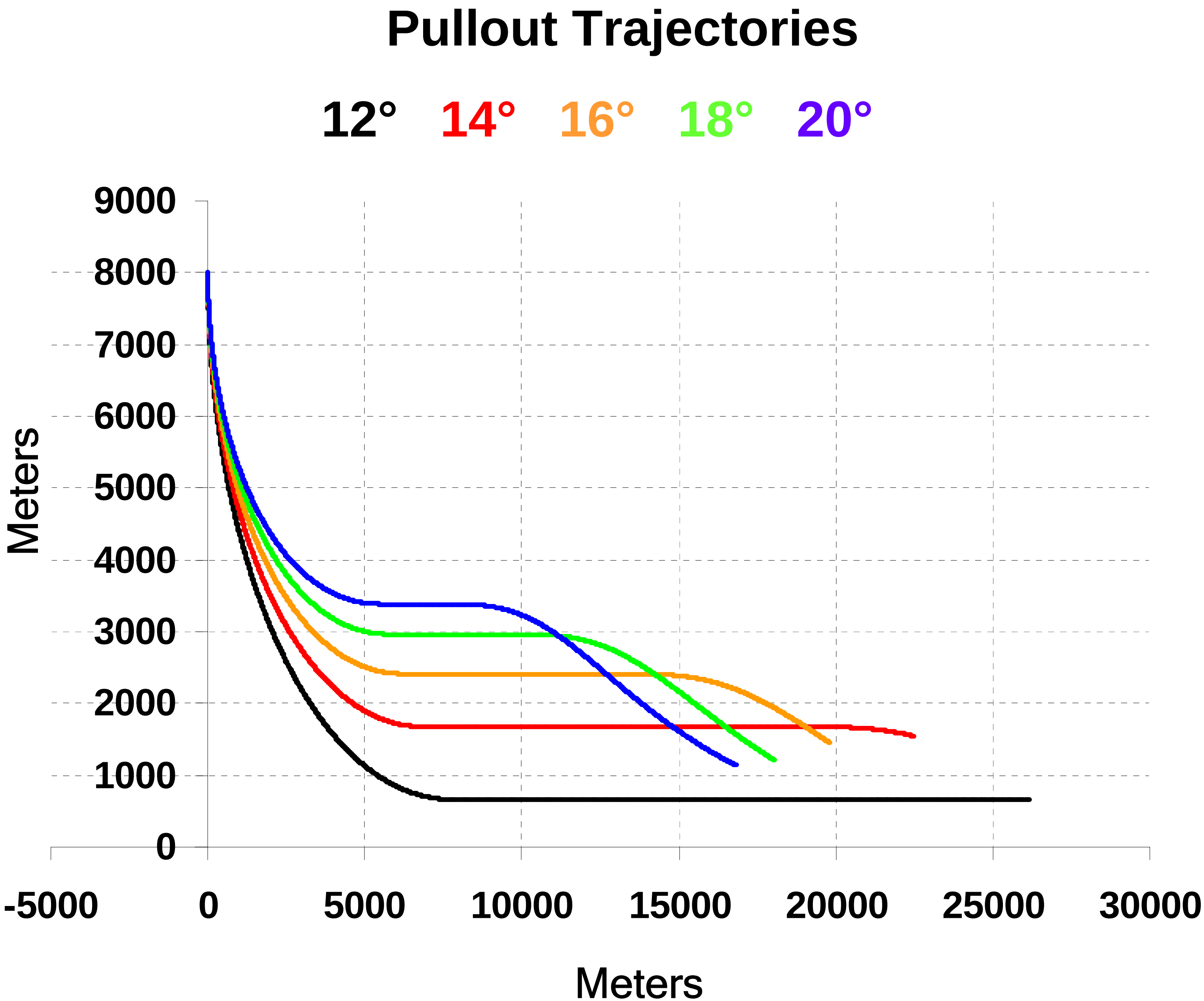
C_L Data for Modeled ARES
Euler3d
Experimental
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-4
-2
0
2
4
6
8
10
12
C_L
Angle of Attack - α



CL & CD Data for Modeled ARES
Euler3d
Experimental
1.5
1
0.5
0
-0.5
-1
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
CL
CD



Angle Convergence
0°
5°
3
2
1
0
-1
-2
-3
-4
-5
0
100
200
300
400
500
600
Pitch Angle (deg)
Time (sec)



Pullout Trajectories
12° 14° 16° 18° 20°
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Meters
-5000
0
5000
10000
15000
20000
25000
30000
Meters

The pitching moment is found by dividing the moment coefficient in the y direction by the planform area and mean aerodynamic chord.

5000	5.00E+02	8.82E-02	-3.64E-03	2.20E+00	-7.32E-03	-2.93E+00	-1.48E-02

$$\frac{-2.93E+00}{6.55\ m^2 * 1.05\ m}$$

$$M = \tfrac{1}{2}\rho v^2 S c C_M$$

This would give a pitching moment coefficient of -.426

Summary

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* Processing speeds are allowing for more intense computations

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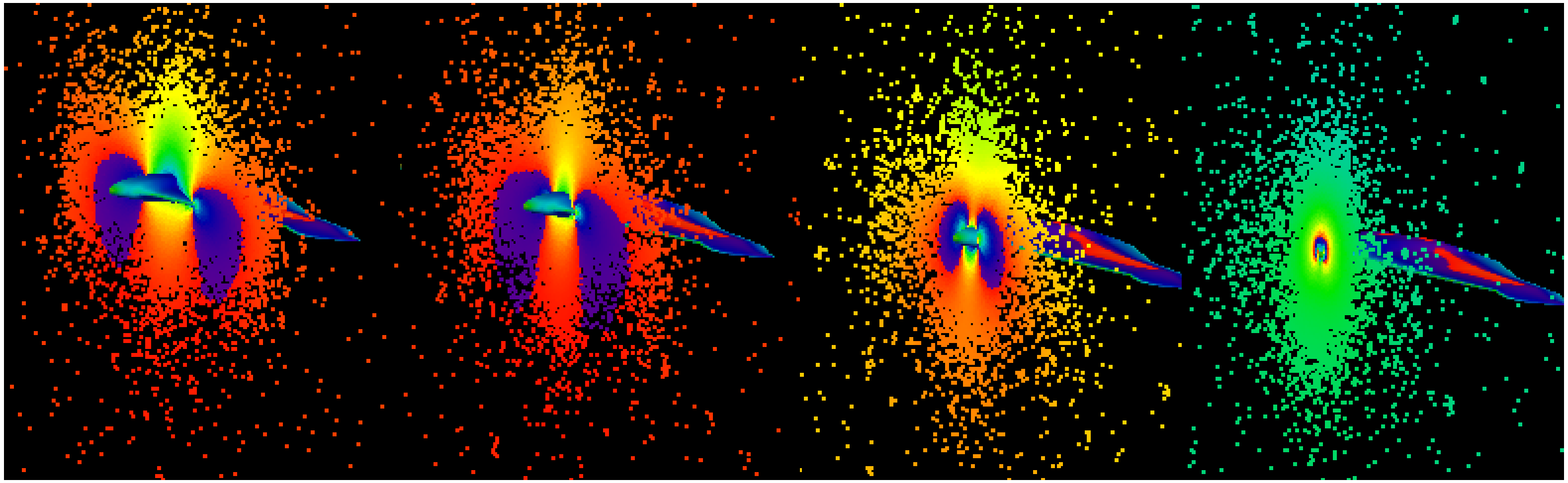

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