

AAAAeroelastic Prediction Workshop

RSW Test Case

Presented by:

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Rectangular Supercritical Wing (RSW)

- Simple, rectangular wing
- Static and forced oscillation pitching motion about the 46% chord
- Fixed transition, 6% chord
- Treated here as rigid
- Highest angle of attack case available was chosen to stress the capabilities of the steady analysis

Known deficiencies:

- Splitter plate deficiencies
 - Small size
 - Located in the tunnel wall boundary layer
 - 6" off of the wall
 - Estimated boundary layer thickness: 12"
- Tunnel wall slots open
 - Open slots have been demonstrated to have a significant effect on steady lift coefficient
- Bad experimental data points, not identified as such in the literature



$M=0.825$, $Re_c=4.0$ million, test medium: R-12

a) Steady Cases

i. $\alpha = 2^\circ$

ii. $\alpha = 4^\circ$

b) Dynamic Cases

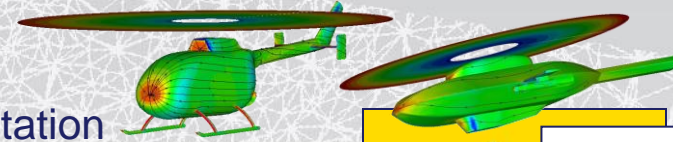
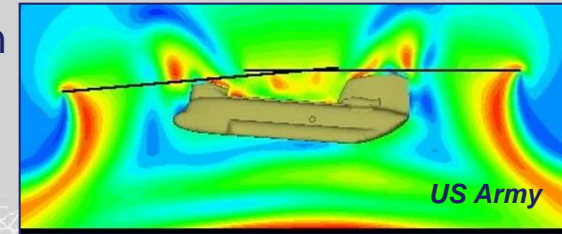
i. $\alpha = 2^\circ$, $\theta = 1.0^\circ$, $f = 10$ Hz

ii. $\alpha = 2^\circ$, $\theta = 1.0^\circ$, $f = 20$ Hz

CFD and Aeroelastic Analysis

<http://fun3d.larc.nasa.gov/>

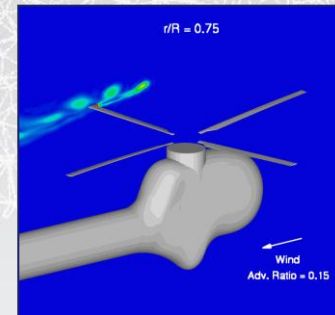
- Solves 2D/3D steady and unsteady Euler and RANS equations on node-based mixed element grids for compressible and incompressible flows
- Supports numerous internal/external efforts across speed range
- General dynamic mesh capability: any combination of rigid/overset/morphing grids, including 6-DOF effects
- Aeroelastic modeling w/ mode shapes, full FEM
- Constrained/multipoint adjoint-based design and mesh adaptation
- Modern software practices including 24/7 testing
- Linear scaling through thousands of cores
- Capabilities fully integrated, very responsive support team, online documentation, training videos, tutorials, etc



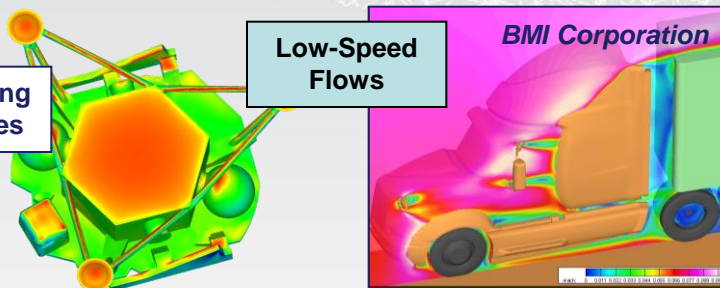
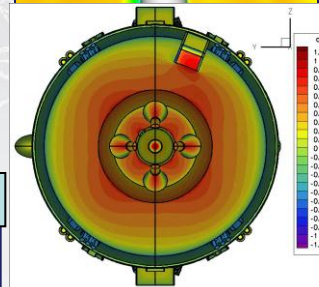
Rotorcraft



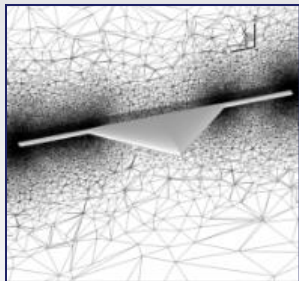
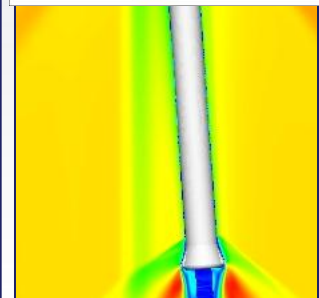
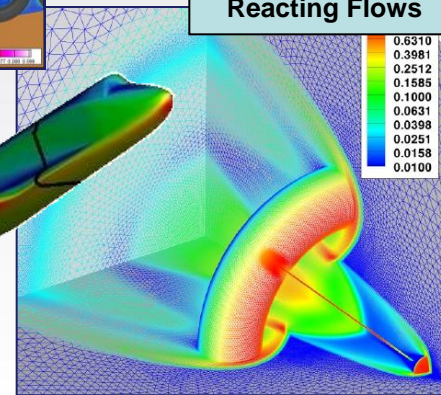
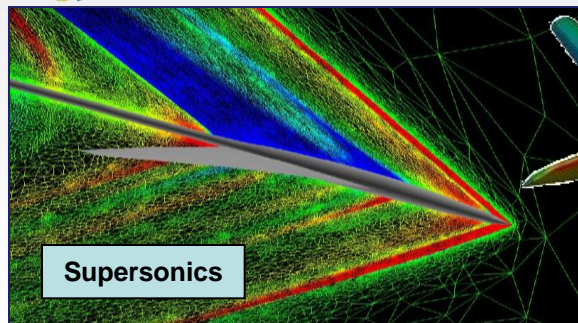
Launch Vehicles



Reacting Flows



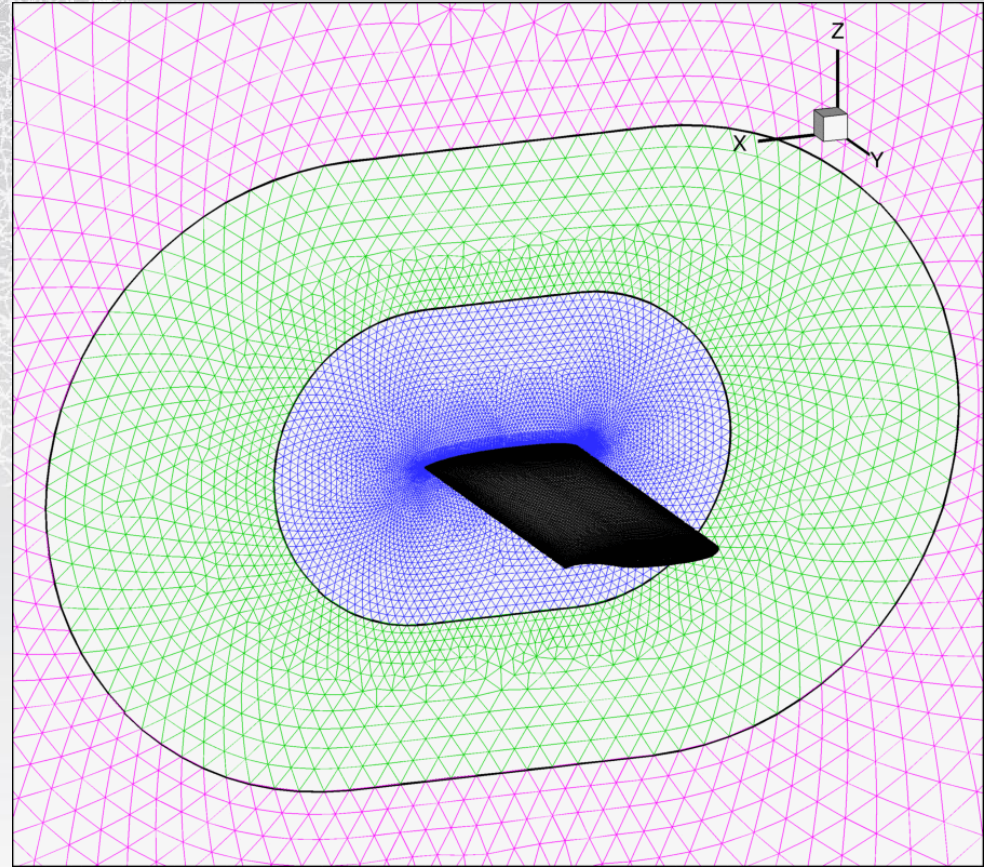
Morphing Vehicles



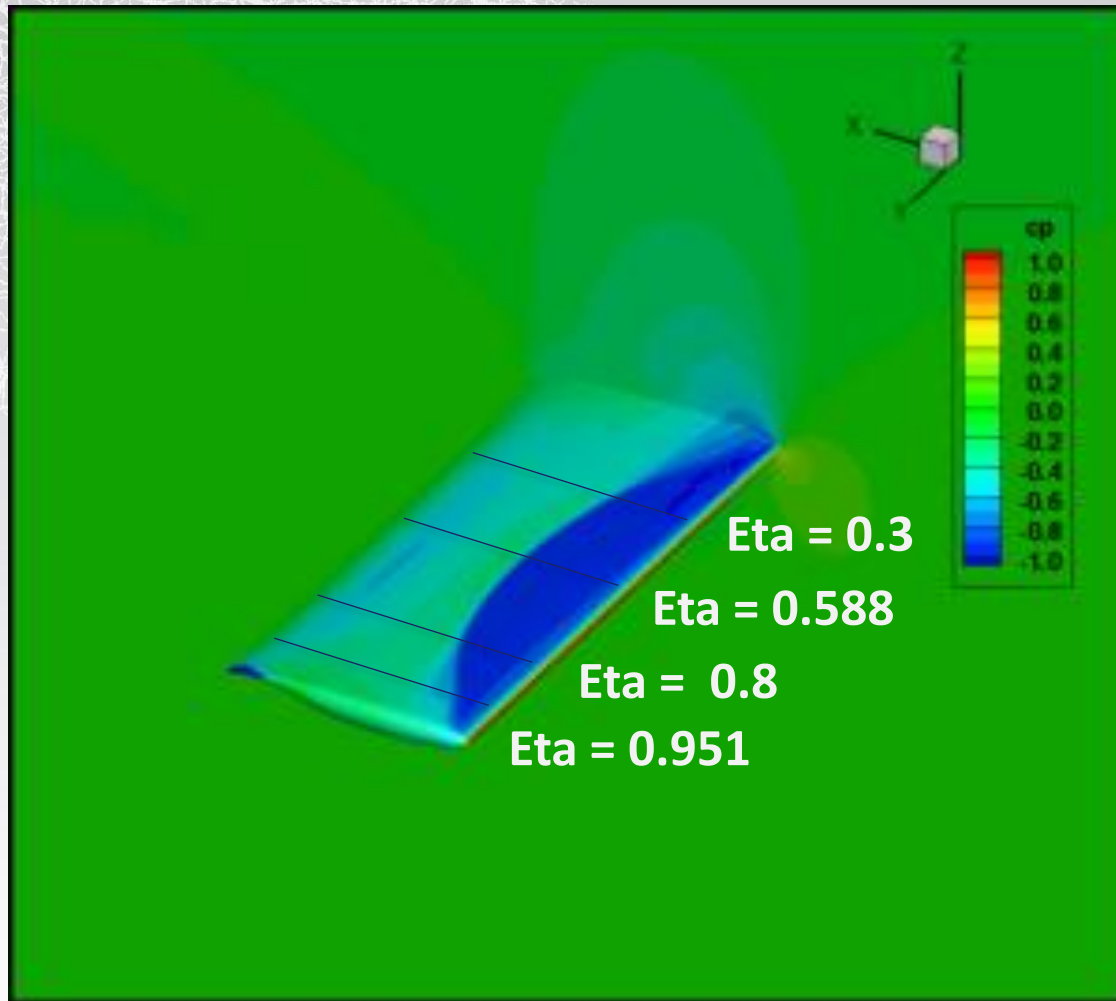
Propulsion Effects

FUN3D Analysis

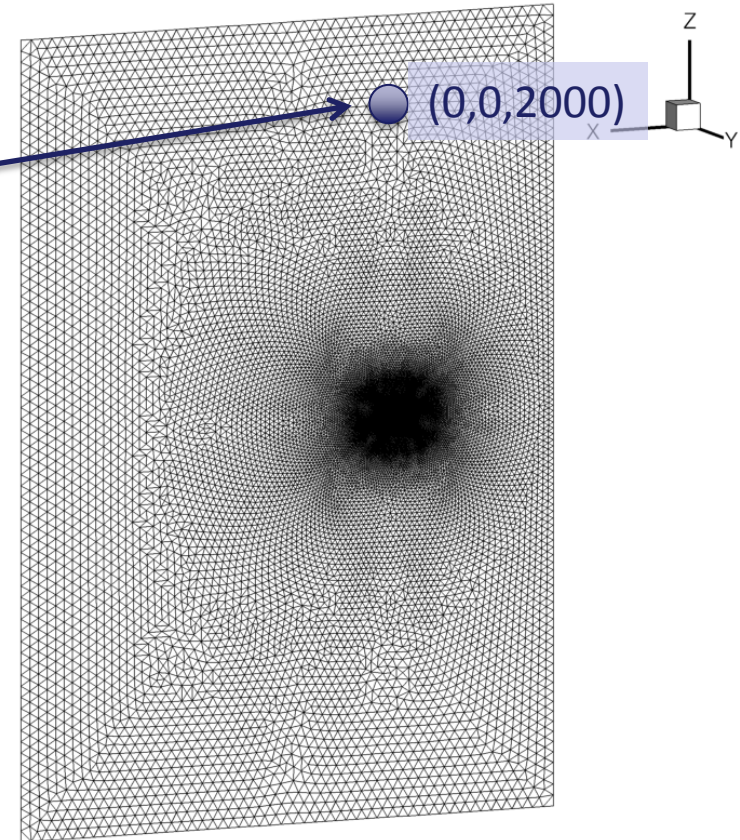
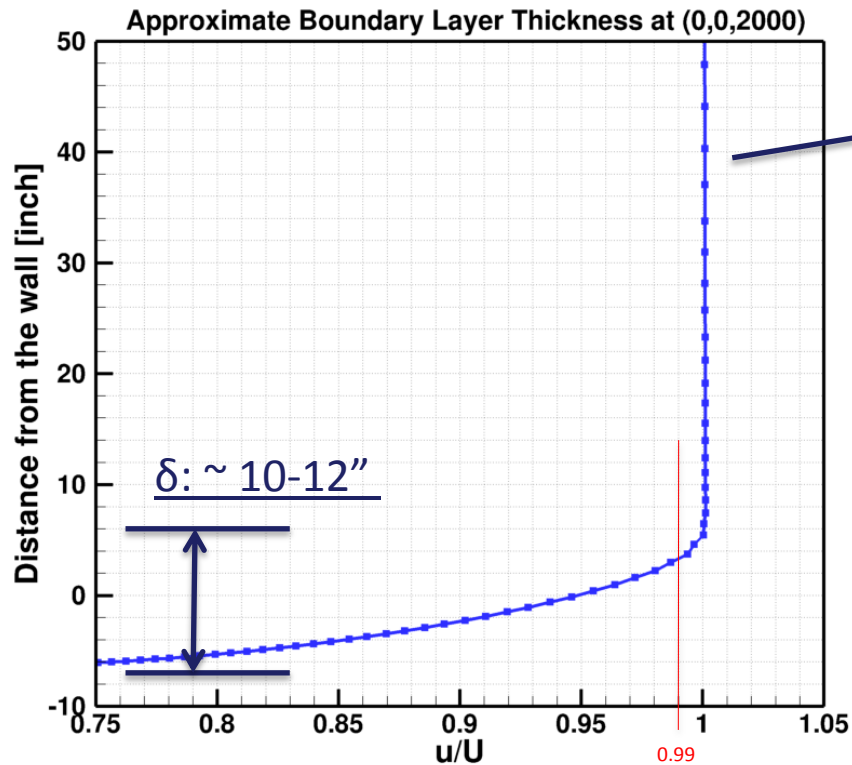
- FUN3D v.11.6
- Roe scheme
- Venkatakrishnan flux limiter
- SA turbulence model
- Mixed element grids:
created by Marilyn Smith
using SolidMesh



FUN3D Analysis

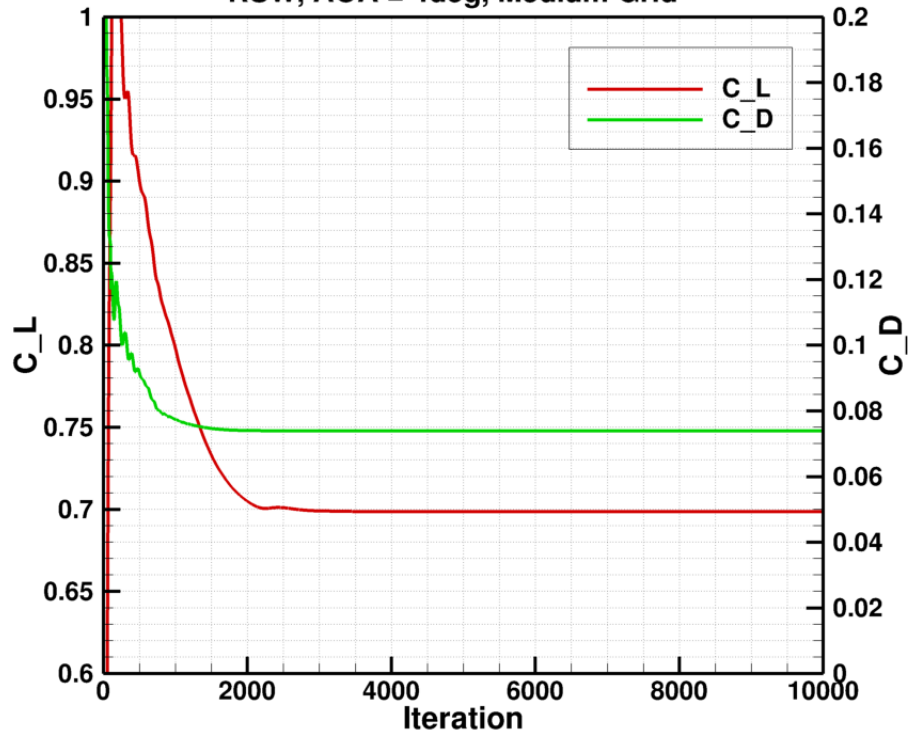


FUN3D Analysis: Boundary Layer Thickness

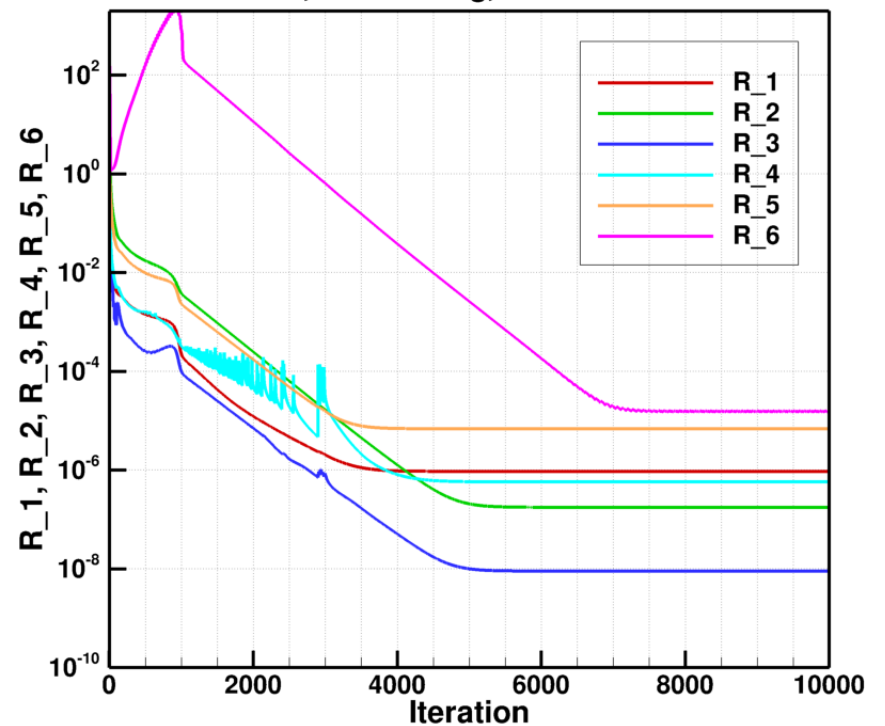


FUN3D Analysis: Convergence

RSW, AOA = 4deg, Medium Grid

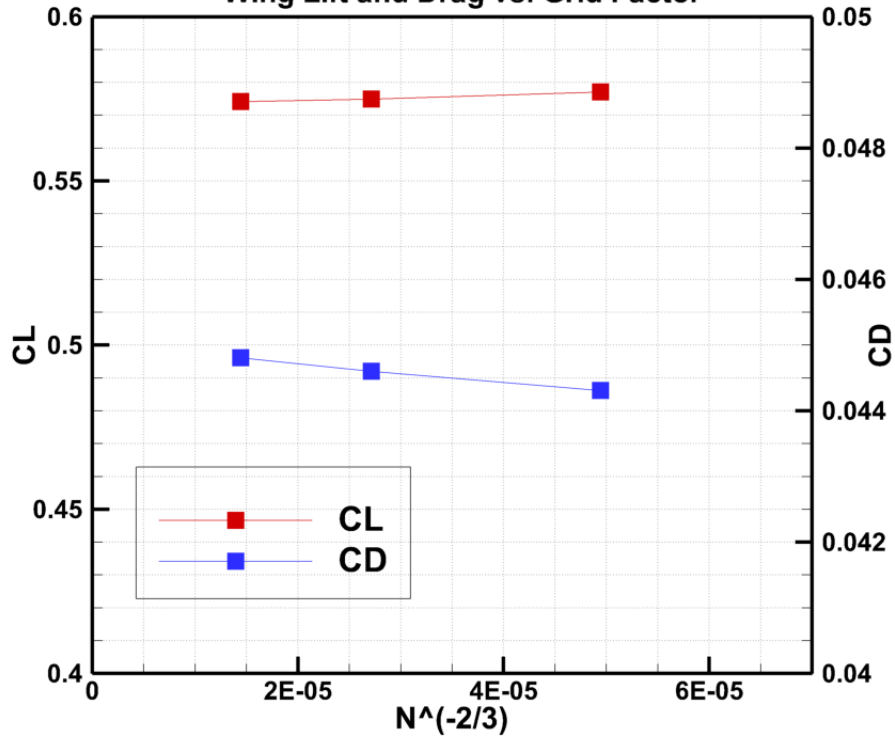


RSW, AOA = 4deg, Medium Grid

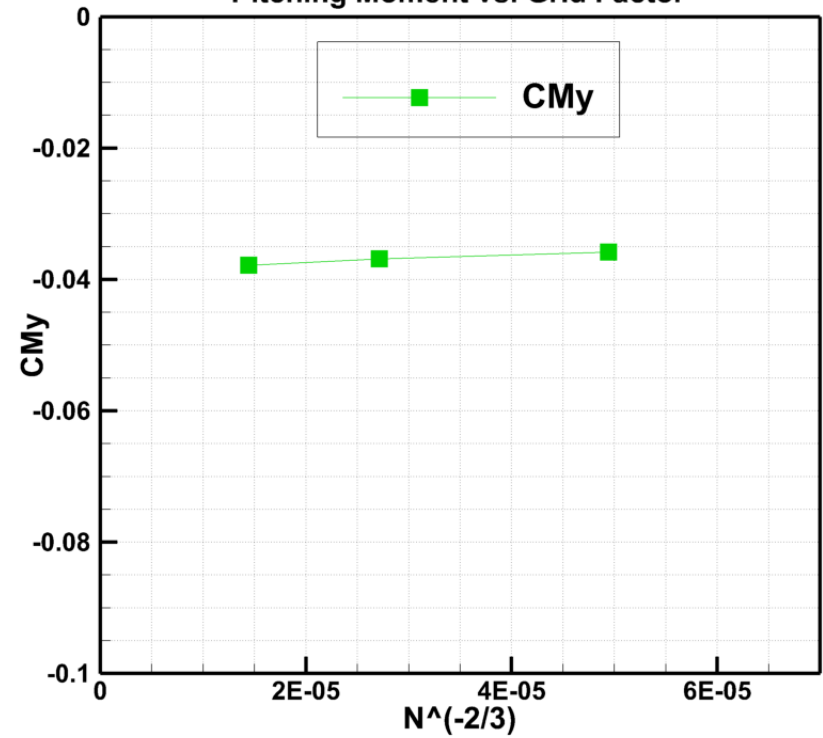


FUN3D Analysis Convergence

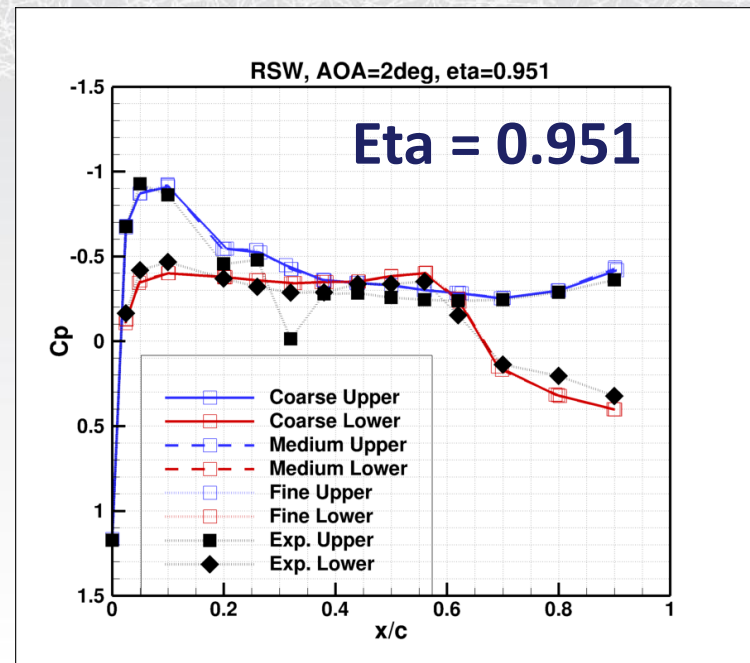
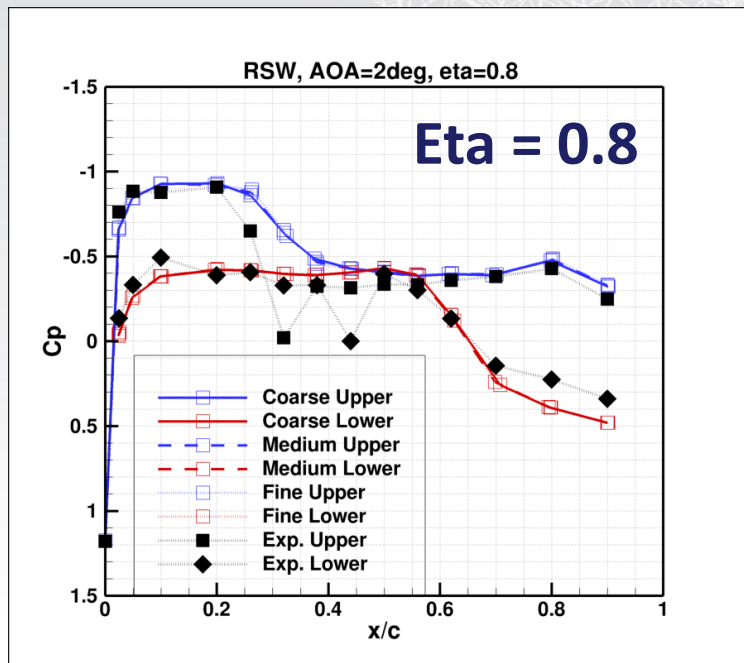
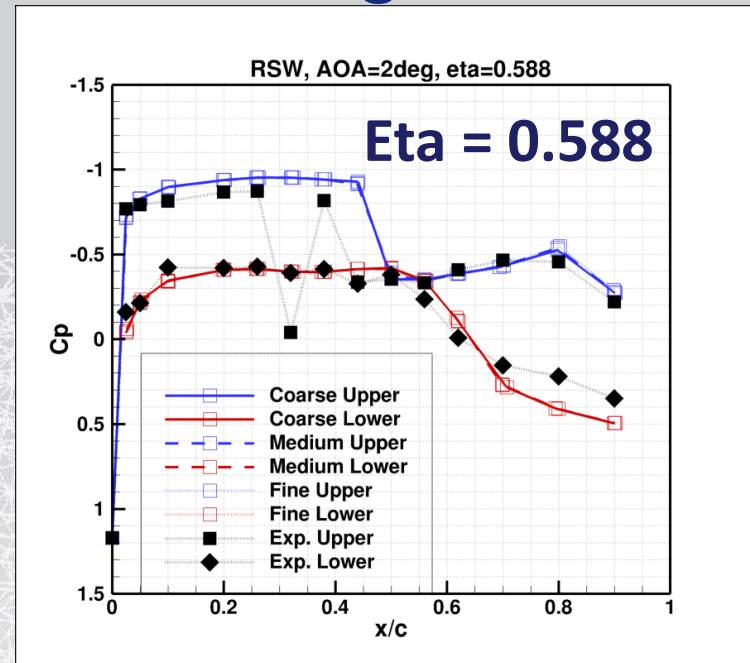
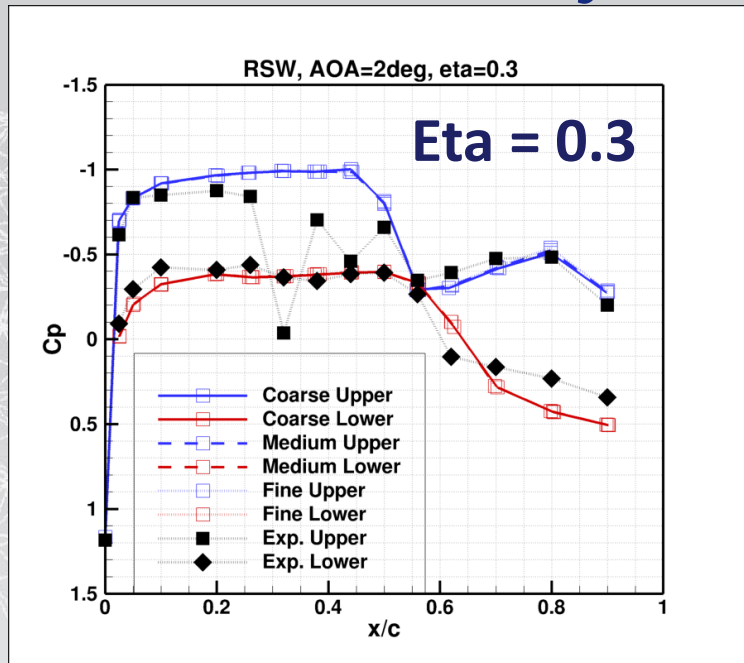
Wing Lift and Drag vs. Grid Factor



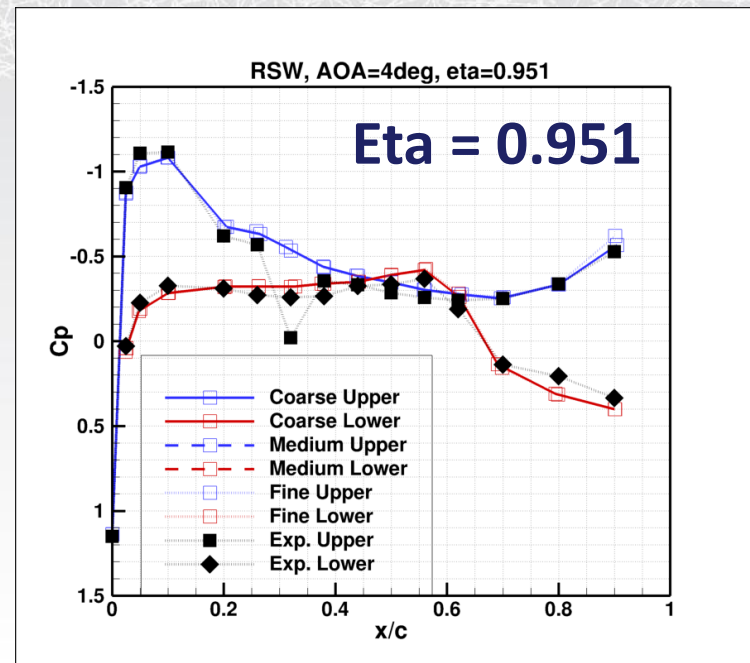
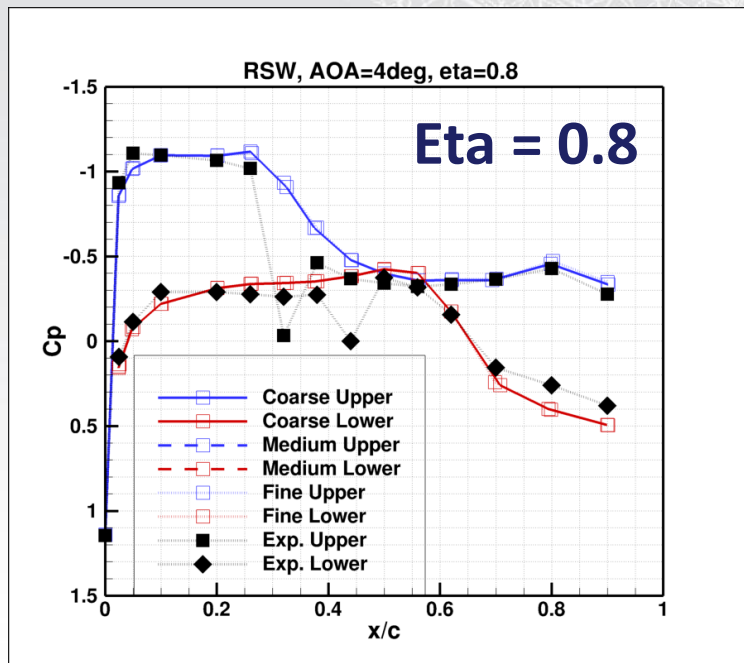
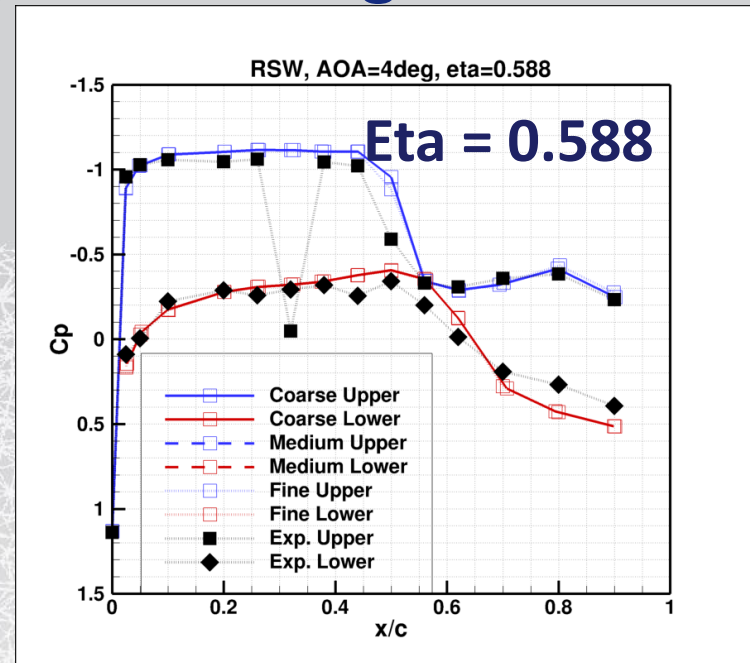
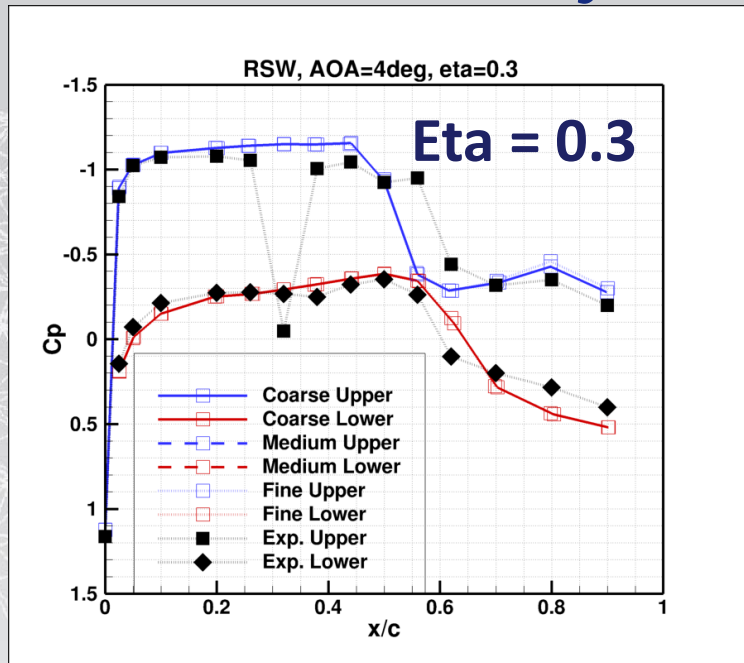
Pitching Moment vs. Grid Factor



Steady State, AOA=2deg



Steady State, AOA=4deg



RSW Dynamic Cases Computational Matrix

10Hz Case

Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.0015 / 64 / 8	0.0015 / 64 / 8	0.0015 / 64 / 8
2	0.00039 / 256 / 8		
3			0.0000976 / 1024 / 4

20Hz Case

Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.00039 / 128 / 8	0.00039 / 128 / 8	0.0039 / 128 / 5
2			
3			0.000049 / 1024 / 2

*dt: timestep size (seconds)
 dn: # of timesteps per cycle
 N: # of cycles

● Analyses not completed

Note: 1. 25 subiterations per time step
 2. Solutions were run for 2 cycles before unsteady surface pressure was collected

RSW Dynamic Cases Computational Matrix

10Hz Case

Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.0015 / 64 / 8	0.0015 / 64 / 8	0.0015 / 64 / 8
2	0.00039 / 256 / 8		●
3		●	0.0000976 / 1024 / 4

20Hz Case

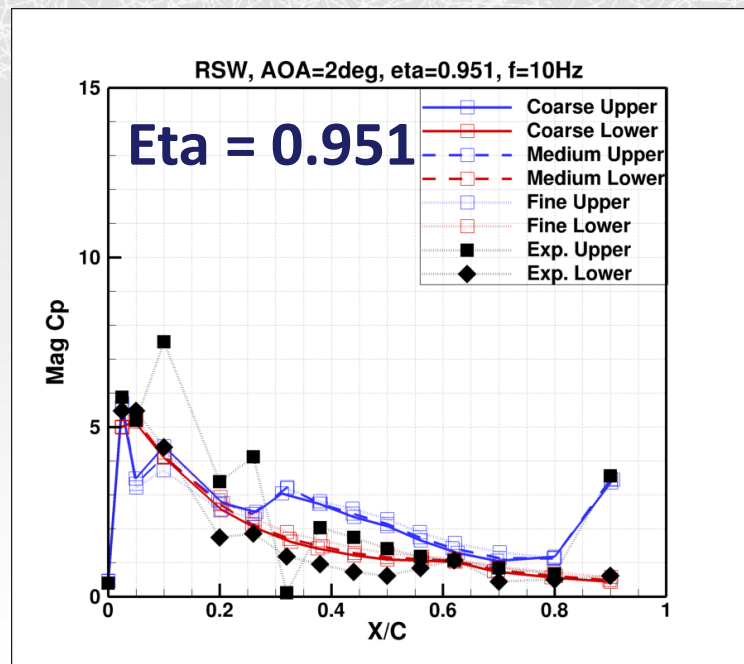
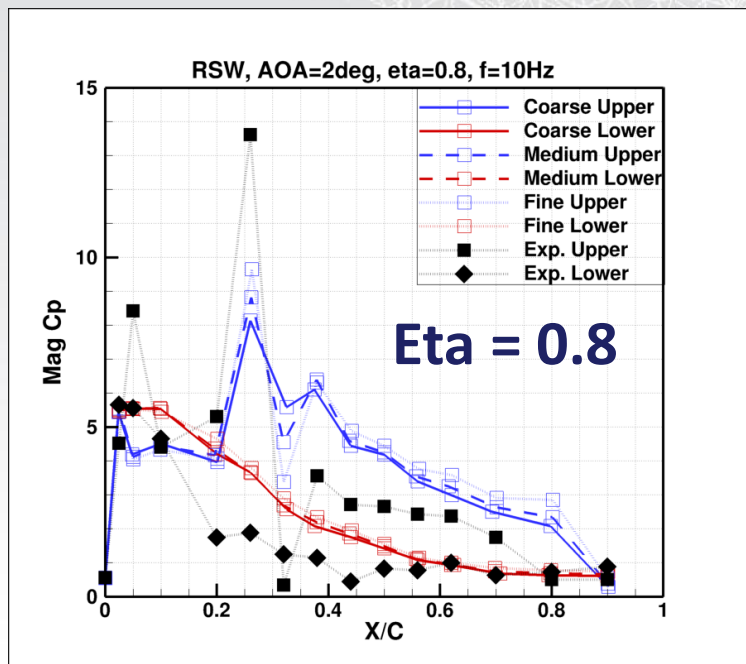
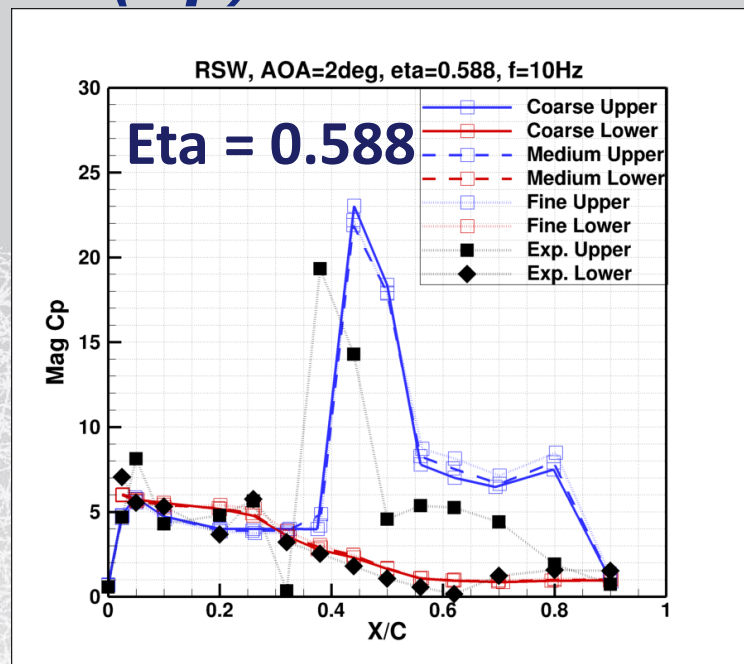
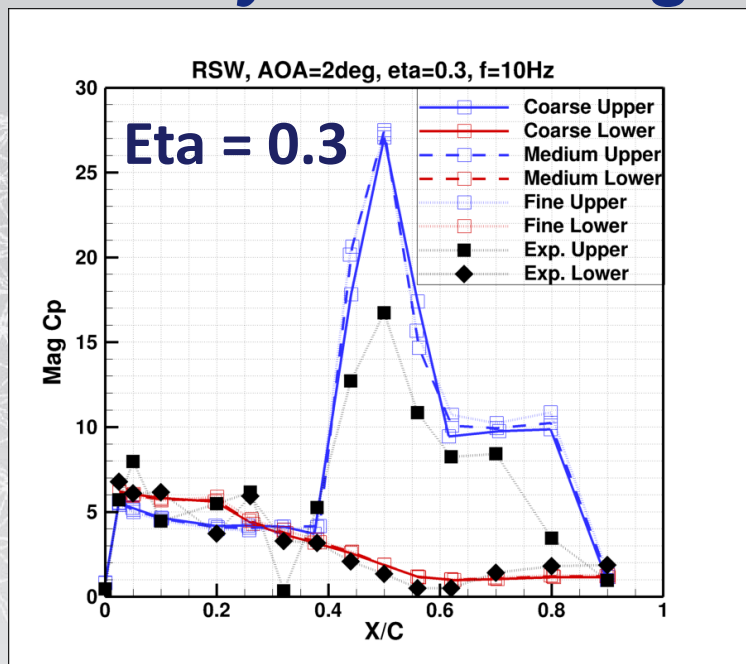
Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.00039 / 128 / 8	0.00039 / 128 / 8	0.0039 / 128 / 5
2	●		●
3		●	0.000049 / 1024 / 2

*dt: timestep size (seconds)
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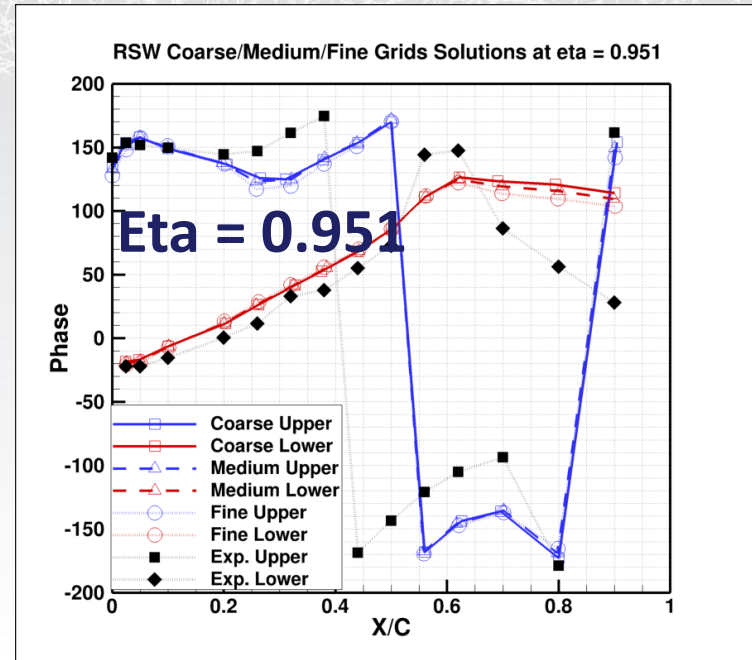
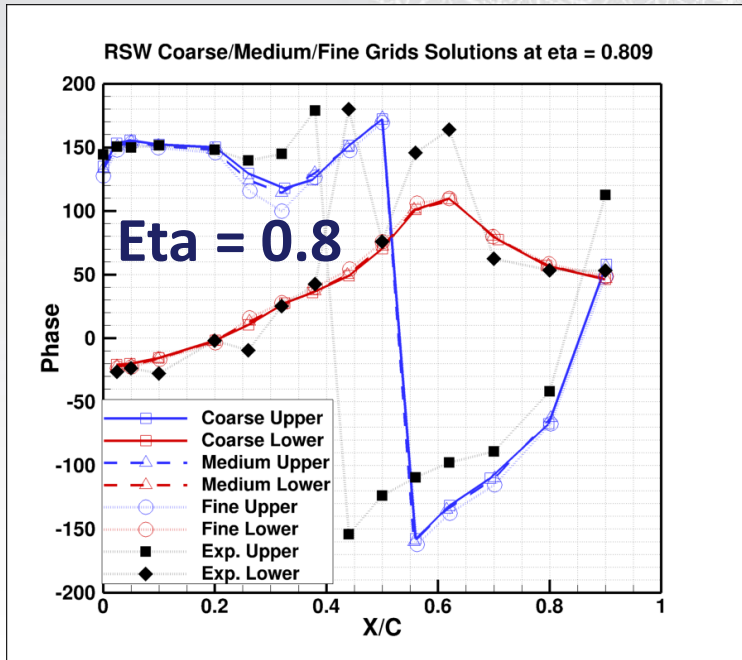
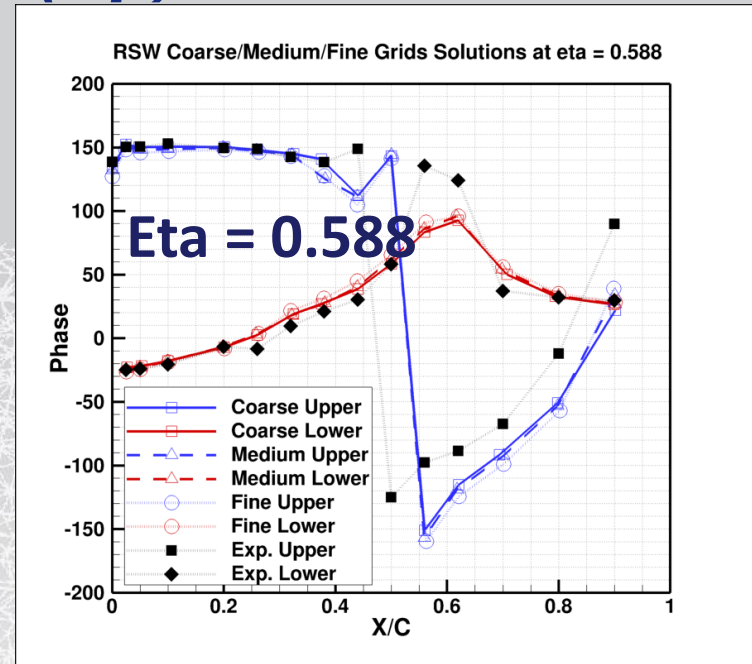
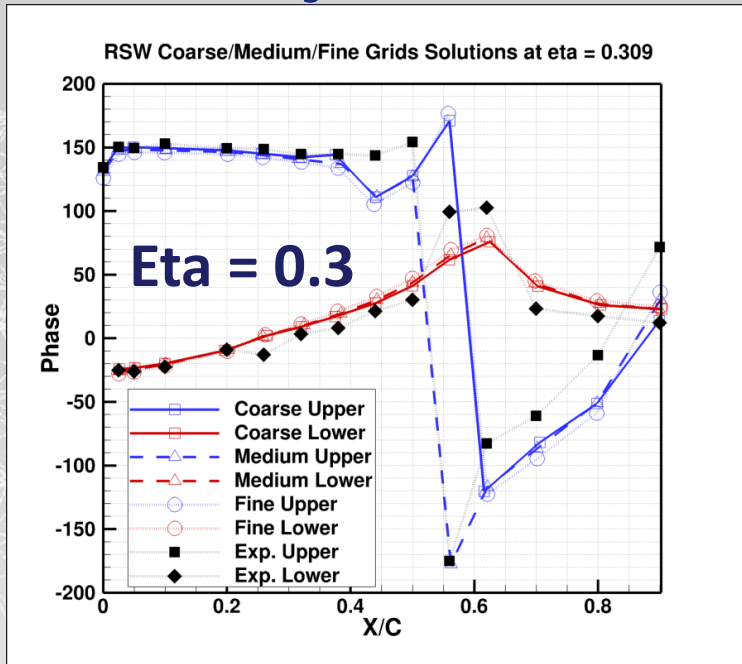
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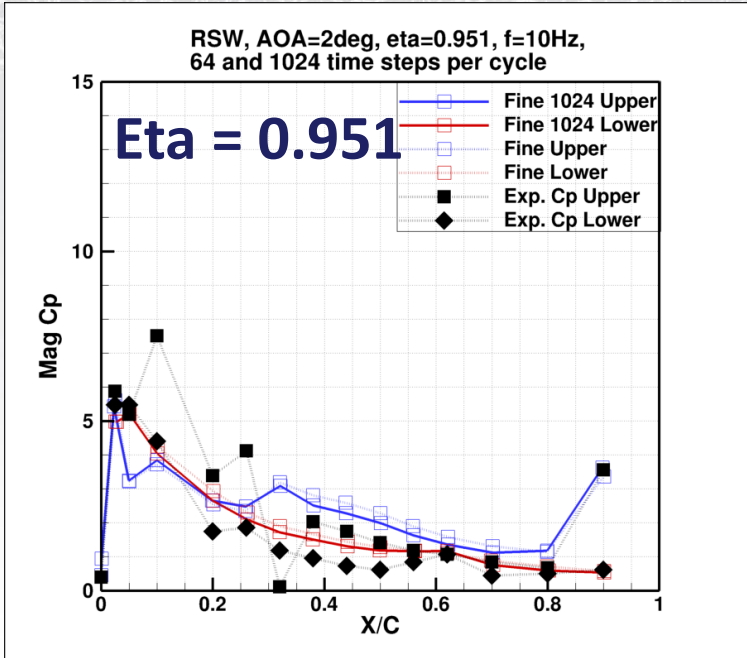
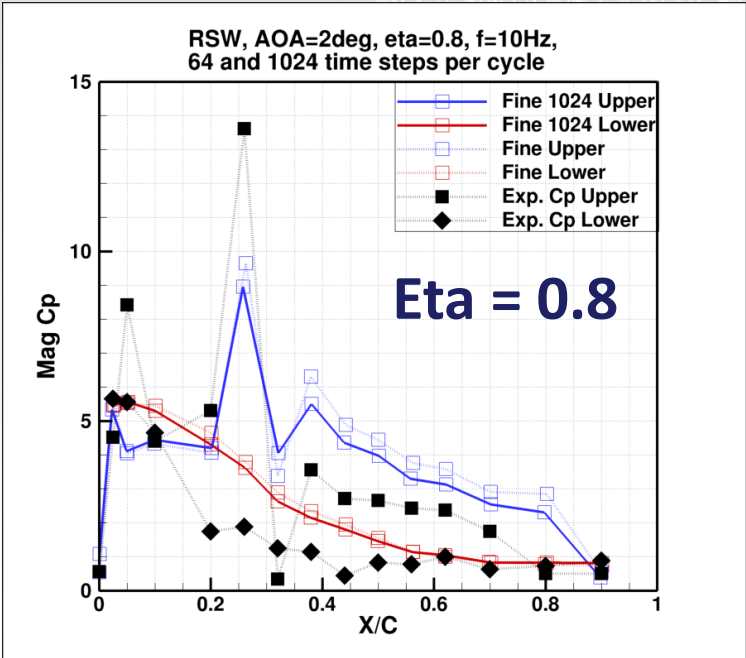
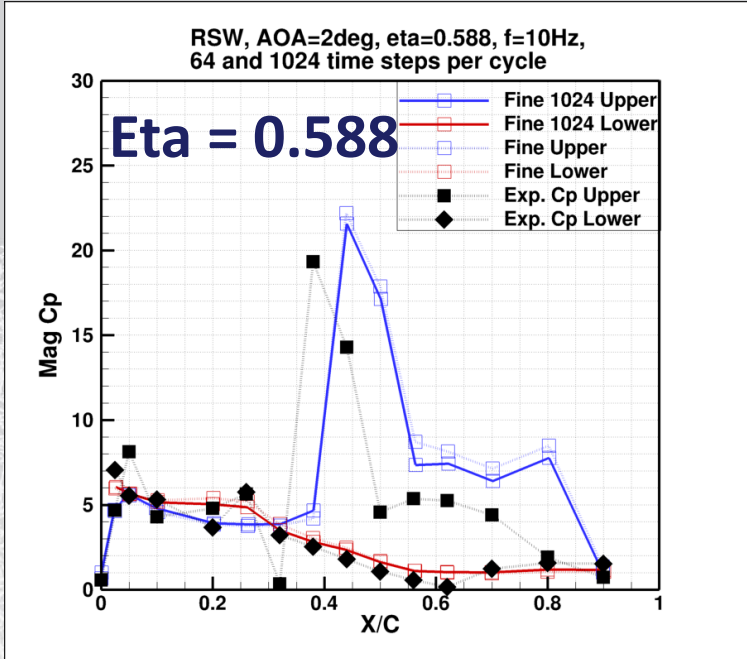
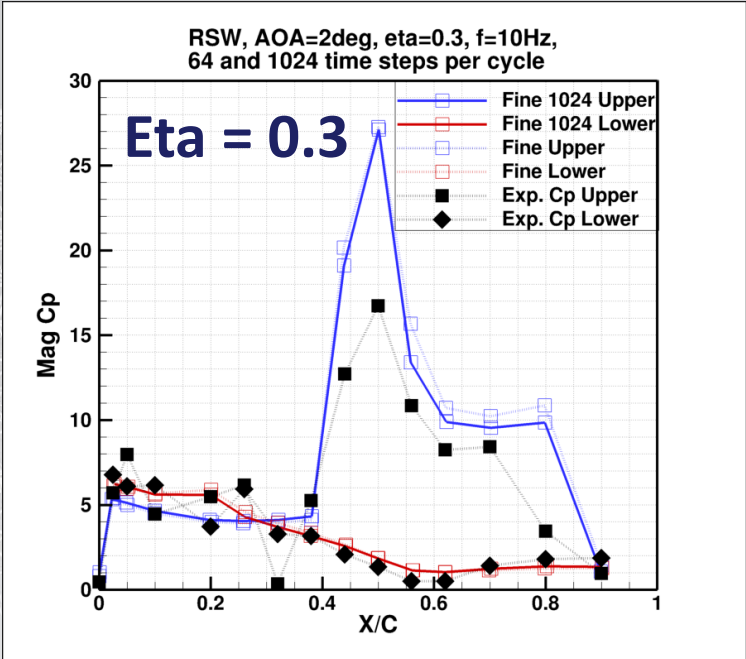
Unsteady $f=10\text{Hz}$ Magnitude (C_p): Grid Resolution



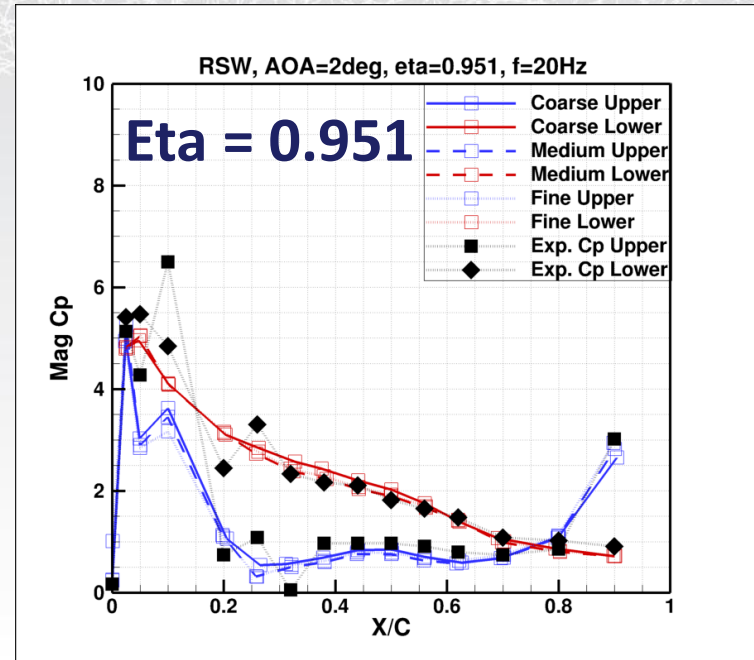
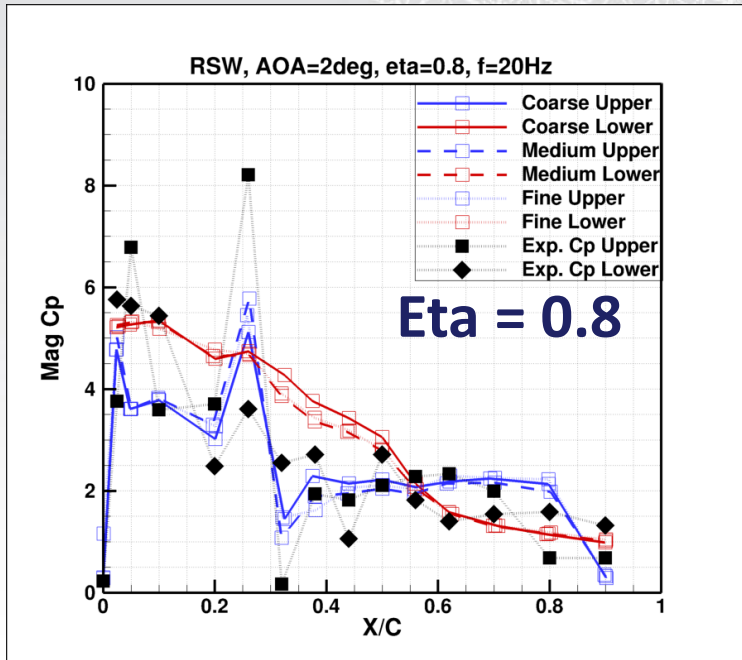
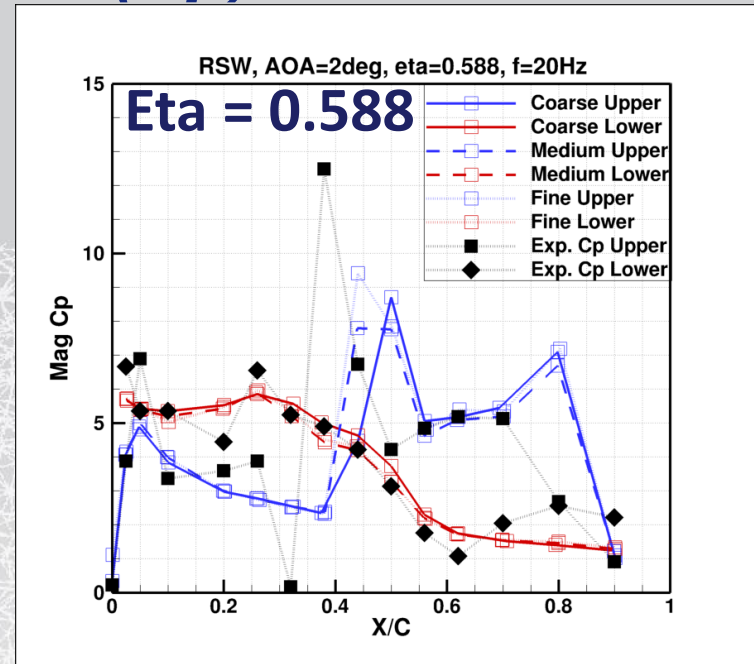
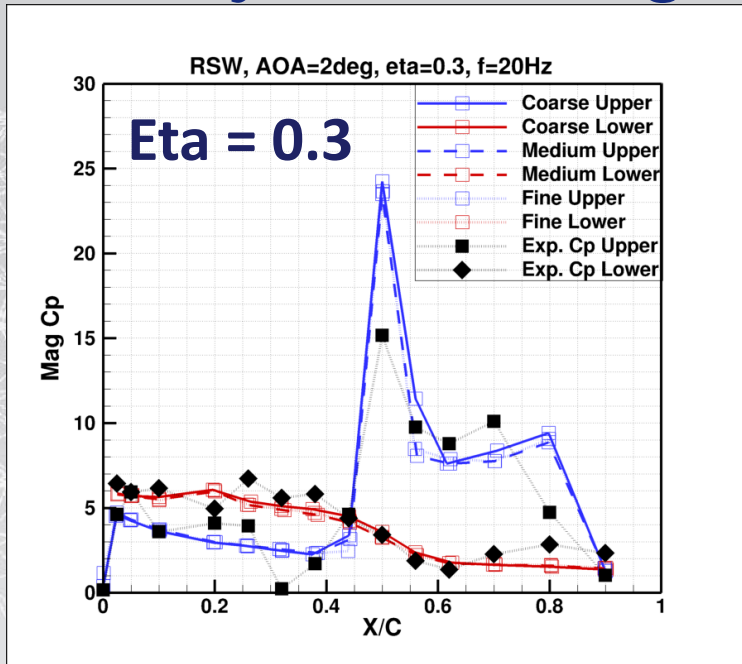
Unsteady $f=10\text{Hz}$ Phase (C_p): Grid Resolution



Unsteady $f=10\text{Hz}$ Magnitude (C_p): Temporal Resolution



Unsteady $f=20\text{Hz}$ Magnitude (C_p): Grid Resolution



Summary

- RSW is a simple geometry and 'simple' flow physics case for AePW with available experimental data
- Some uncertainty is associated with a tunnel wall and splitter plate
- Turbulence model and subiteration convergence needs to be further investigated