Use of NSU3D for Transonic Drag Prediction

David W. Levy
Cessna Aircraft Co.

Overview

- NSU3D Description
- Grid modifications
- Case1
- Case 2
- Cases 3-4
- Conclusions/Recommendations

NSU3D Characteristics

- Thin-layer Navier-Stokes
- RANS, Spalart-Allmaras turb. model
- Unstructured grids, nodal, mixed elements
- Central differencing w/ matrix dissipation
- Agglomeration multigrid
- Implicit lines through boundary layer
- Parallel implementation

Grid Modifications

- Standard unstructured nodal grid
- Used VGRID to generate refined grid
- 17 nodes across wing trailing edge
- 65% Global refinement:
  - 3 M volume nodes (std: 1.6M)
  - 73K viscous surface nodes (std: 36K)
- 4.2 GB memory required

Computer System Stats

- Grid generated and preprocessed on SGI Octane, dual 300Mhz R12000, 2GB RAM
- Solutions run on 8 dual-node “Beowulf” type system
- Alpha VP2000 motherboards
- 16 GB total memory
- 8 hour run time for 3M grids (typical)

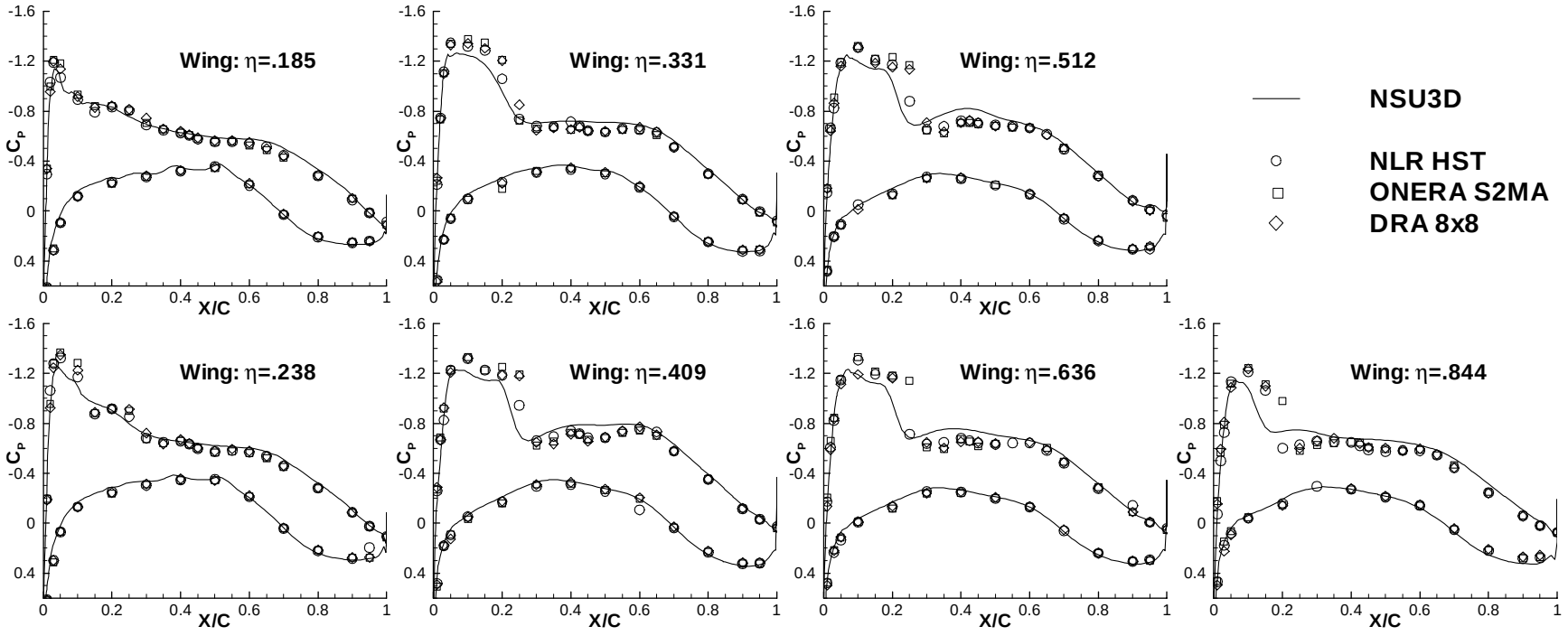
Forces/Moments: Case 1

$M_\infty = .75$, $R_{Nc} = 3x10^6$, Std Grid (1.6M nodes)

	NSU3D	Experiment
C_L	.4995	.500
α	-.248°	.2°
C_D	.02899	.0286 (Avg)
C_M	-.1540	-.132 (Avg)

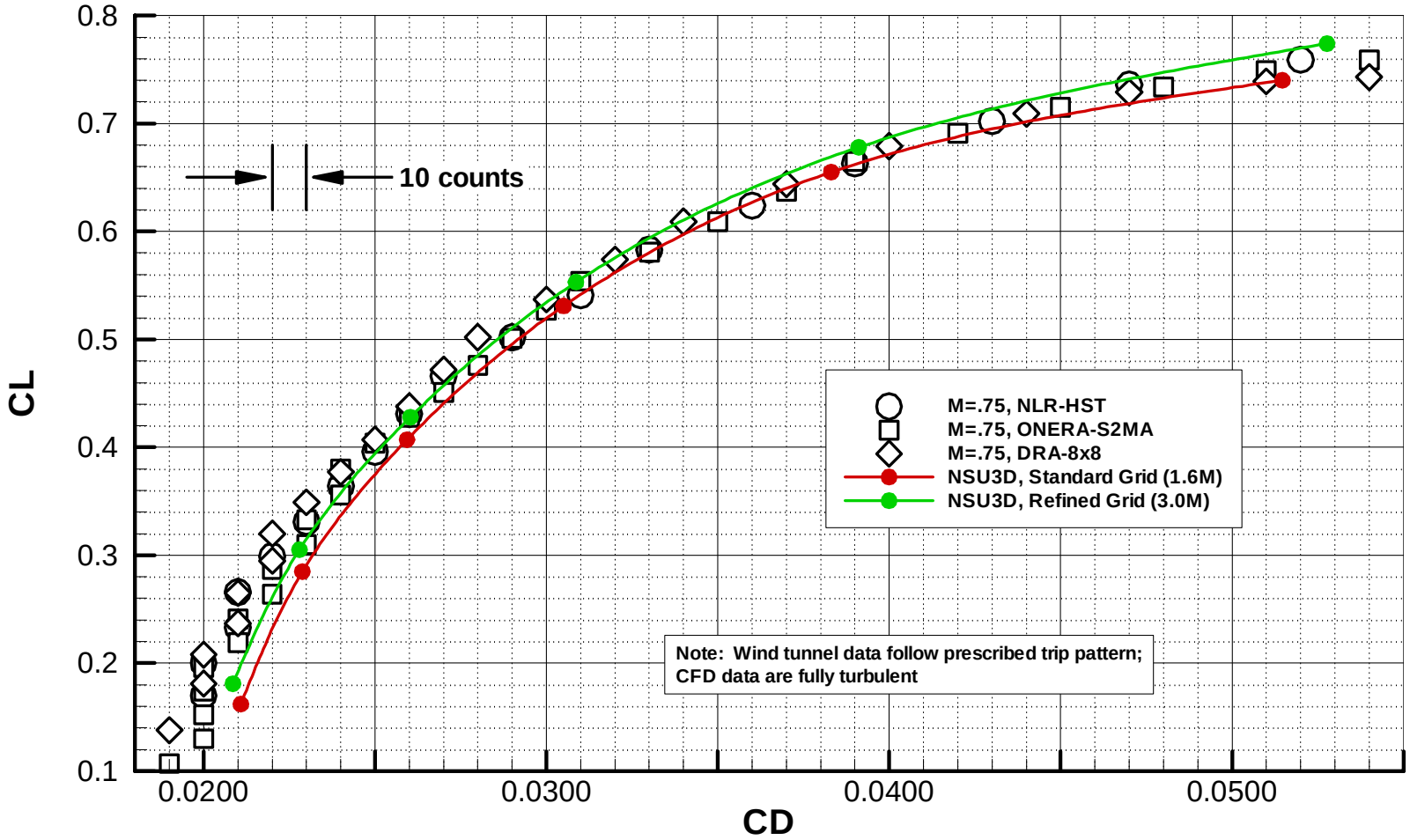
Pressure Profiles: Case 1

M_∞= .75, C_L=.50, R_{Nc}= $3x10^6$, Std Grid (1.6M nodes)



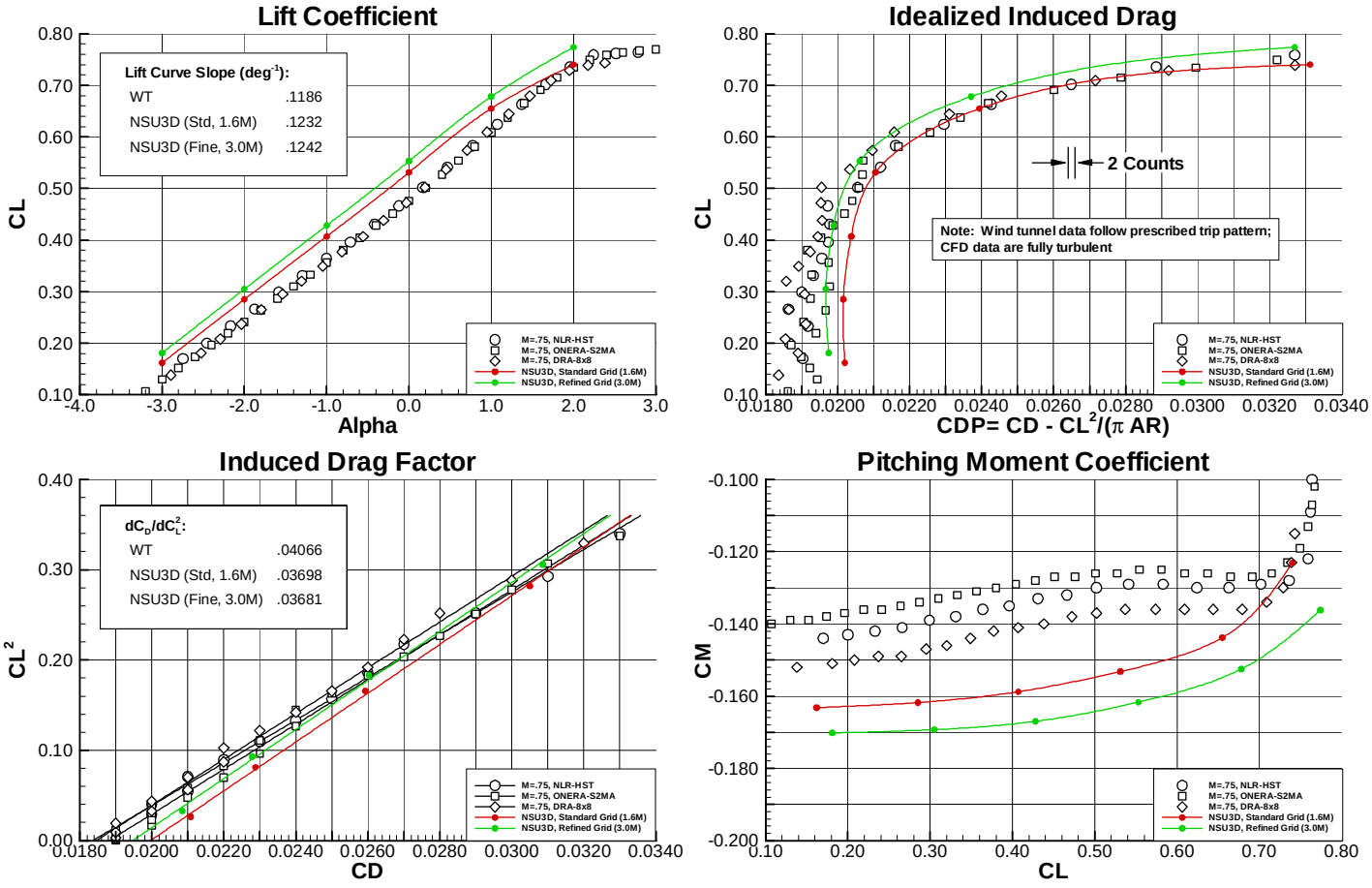
Drag Polar: Case 2

$M_\infty = .75$, $R_{Nc} = 3x10^6$, Std and Fine Grids



Forces/Moments: Case 2

$M_\infty = .75$, $R_{Nc} = 3x10^6$, Std and Fine Grids

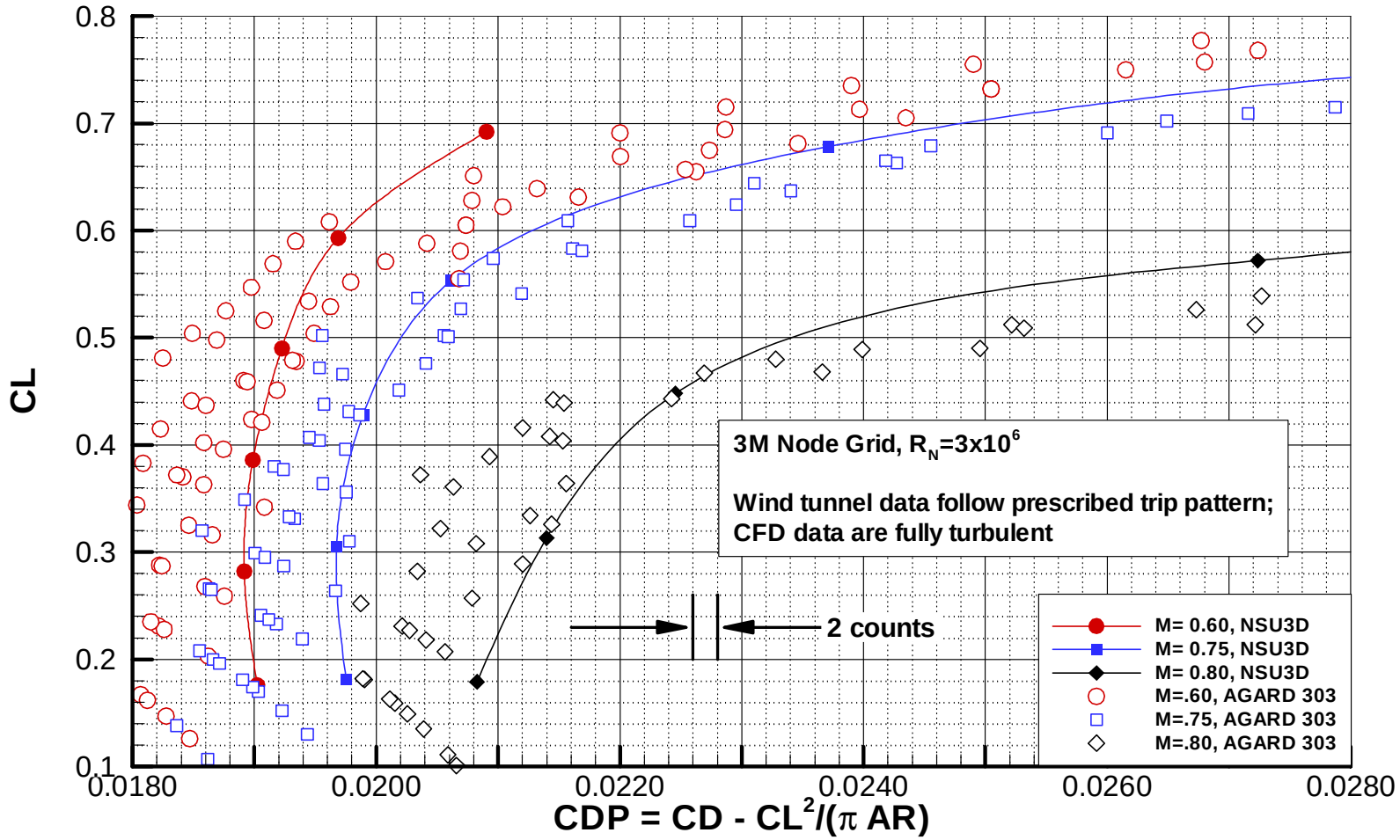


Cases 3-4 Run Matrix

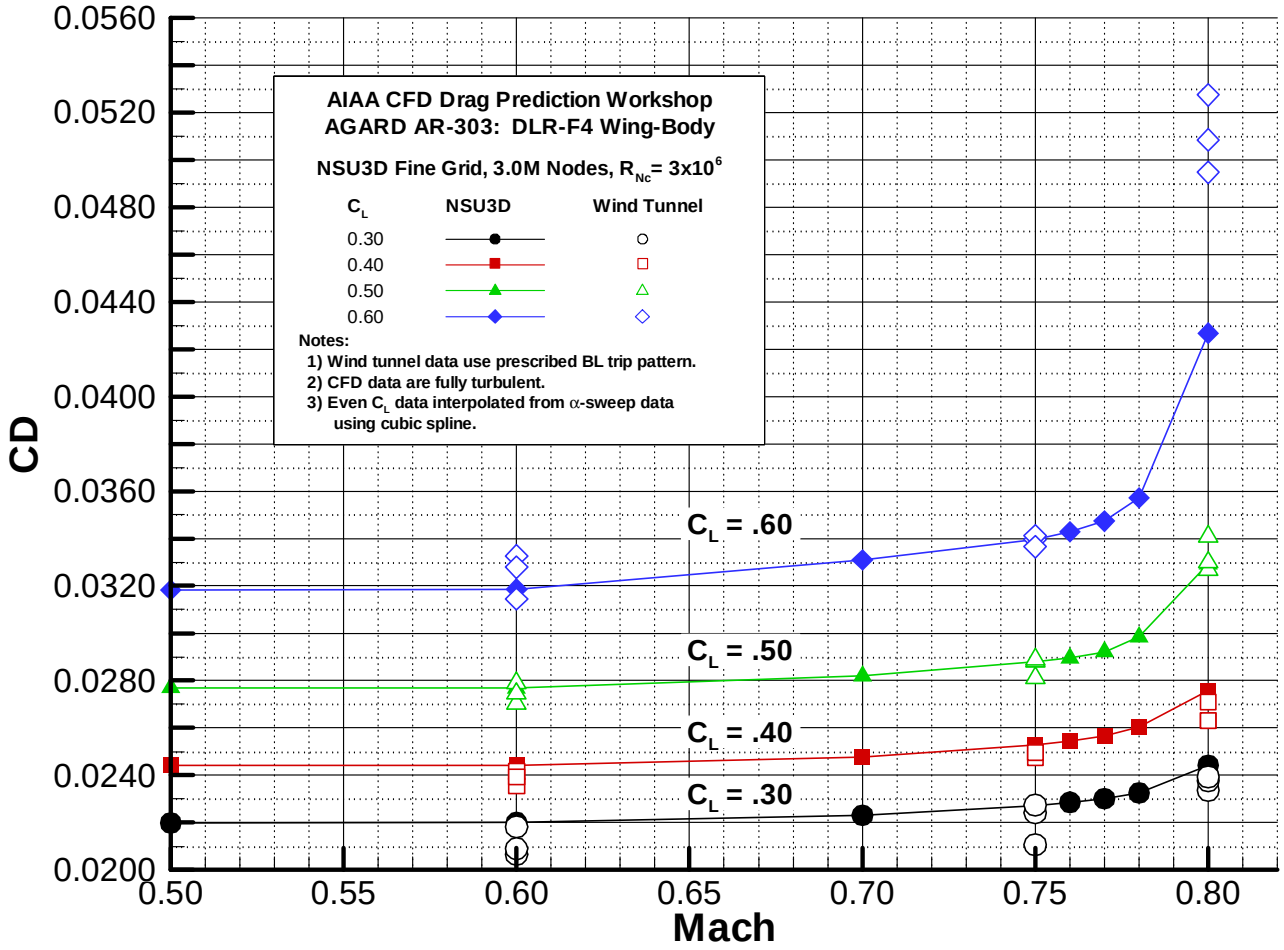
A/M	.50	.60	.70	.75	.76	.77	.78	.80
-3	---	x	---	x	x	x	x	x
-2	C	x	x	x	x	x	x	x
-1	C	x	x	x	x	x	x	x
0	C	x	x	x	x	x	x	R
1	C	x	x	x	C	C	R	R
2	x	x	---	C	---	--	---	R

x: Normal run
C: Extra convergence required
R: Restart from previous solution

Cases 3-4 Idealized Profile Drag



Cases 3-4 Mach Sweep



Conclusions/Recommendations

- Basic drag levels well predicted.
- Induced drag and separation underpredicted.
- Mach number trends consistent w/ expmt.
- NSU3D a practical tool for drag estimation.
- More study on induced drag and separation.
- Database for correlation to flight.