AIAA DPW4

NSU3D - Cessna

Mark Chaffin – Cessna Aircraft Company

Grid differences

Cessna Grid

- **Faster BL growth rate: R1=0.15, R2=0.06**
- **Volume sources at wing root**
- **Discrete linear sources on fuselage**
- **Med. grid "ifact"=1.0**
- **Better surface resolution: ~50% on fuselage, ~22% on wing and tail**

NASA Grid

- **Slower BL growth rate: R1=0.12, R2=0.02**
- **Volume sources at wing/ tail TE**
- **Surface sources on fuselage**
- **Med. grid "ifact"=1.2175**
- **Better boundary layer resolution: ~25% more cells**

Additional Cessna grid

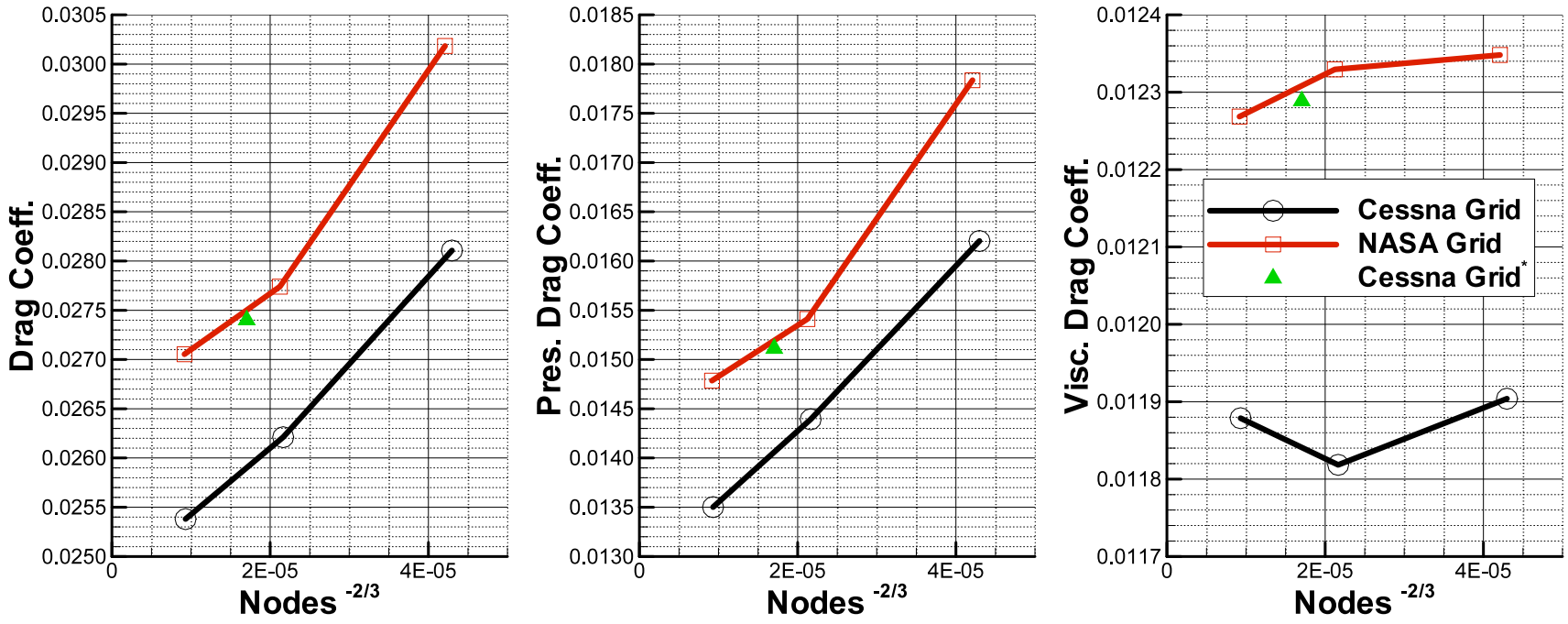
Cessna Grid

- **Faster BL growth rate: R1=0.15, R2=0.06**
- **Med. grid "ifact"=1.0**
- **38.1 million viscous cells**
- **9.93 million nodes**

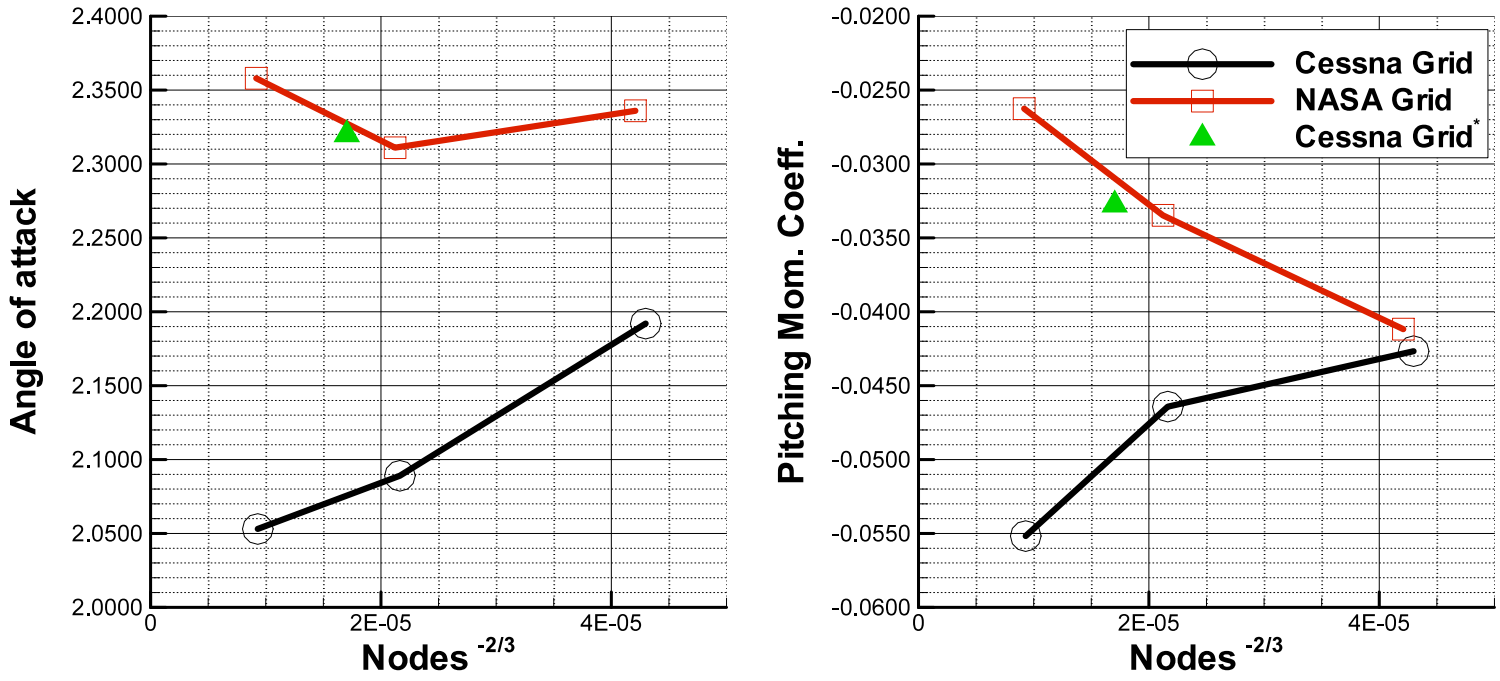
Cessna* Grid

- **Slower BL growth rate: R1=0.12, R2=0.02**
- **Med. grid "ifact"=1.0**
- **66.2 million viscous cells (173%)**
- **14.22 million nodes (143%)**
- **Same surface face resolution**

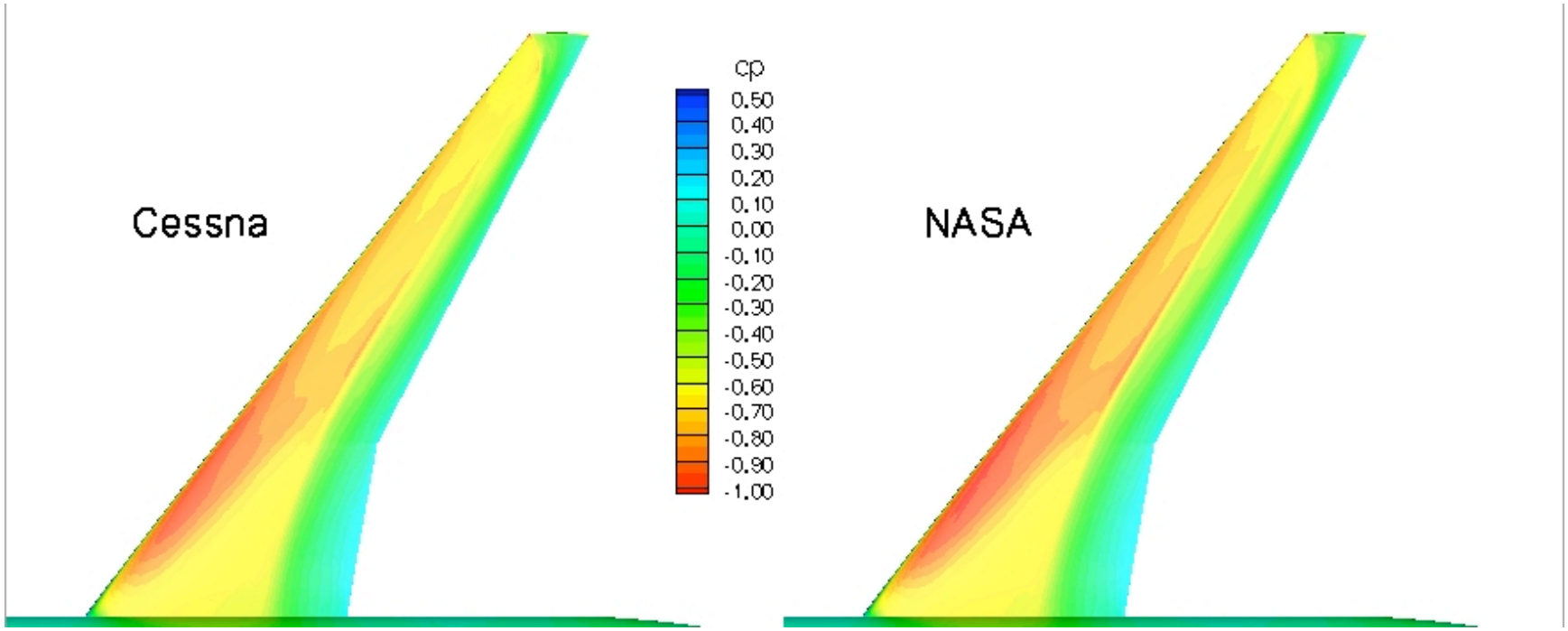
Case 1.1: Grid Convergence - Drag



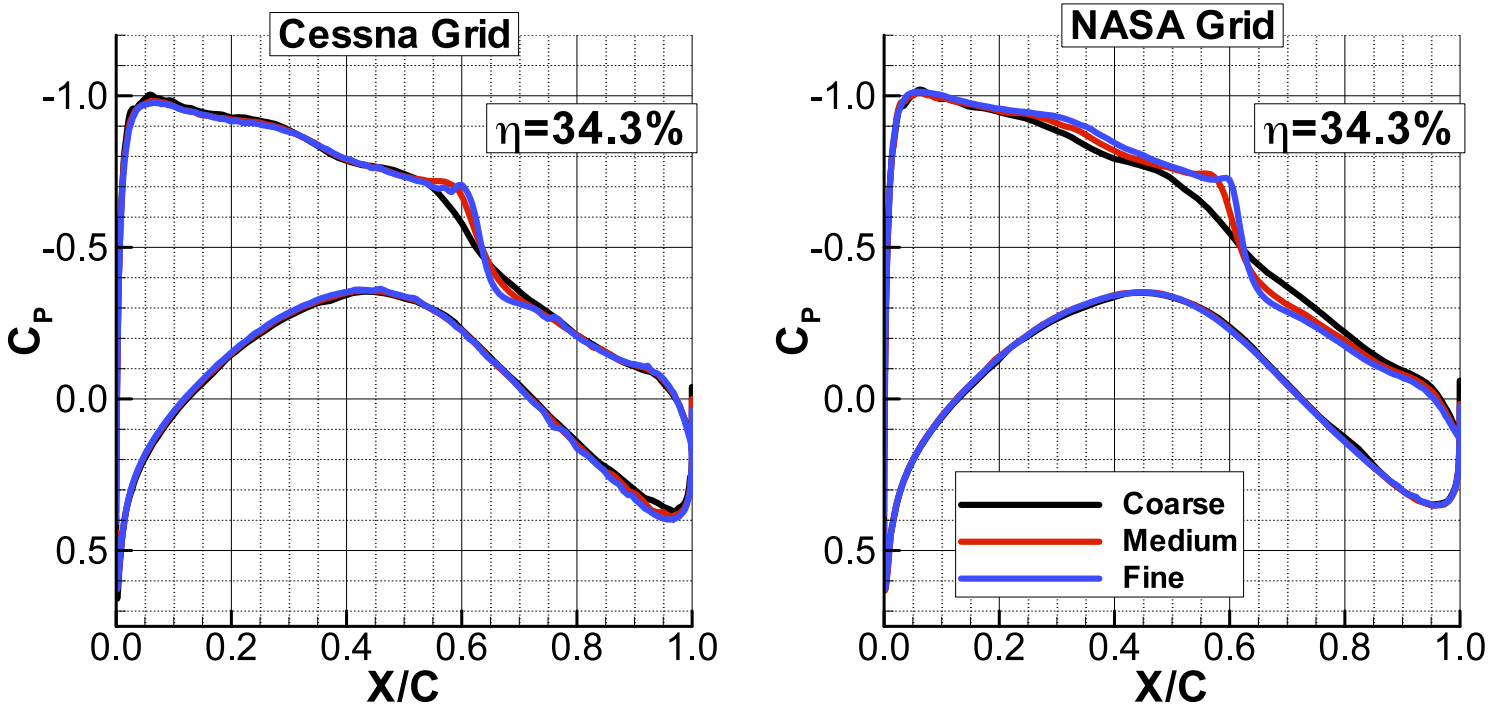
Case 1.1: Grid Convergence – α, c_m



Case 1.1: C_P contours: M=0.85, C_L=0.50, Re=5x10^6



Case 1.1: C_P distribution: M=0.85, C_L=0.50, Re=5x10^6



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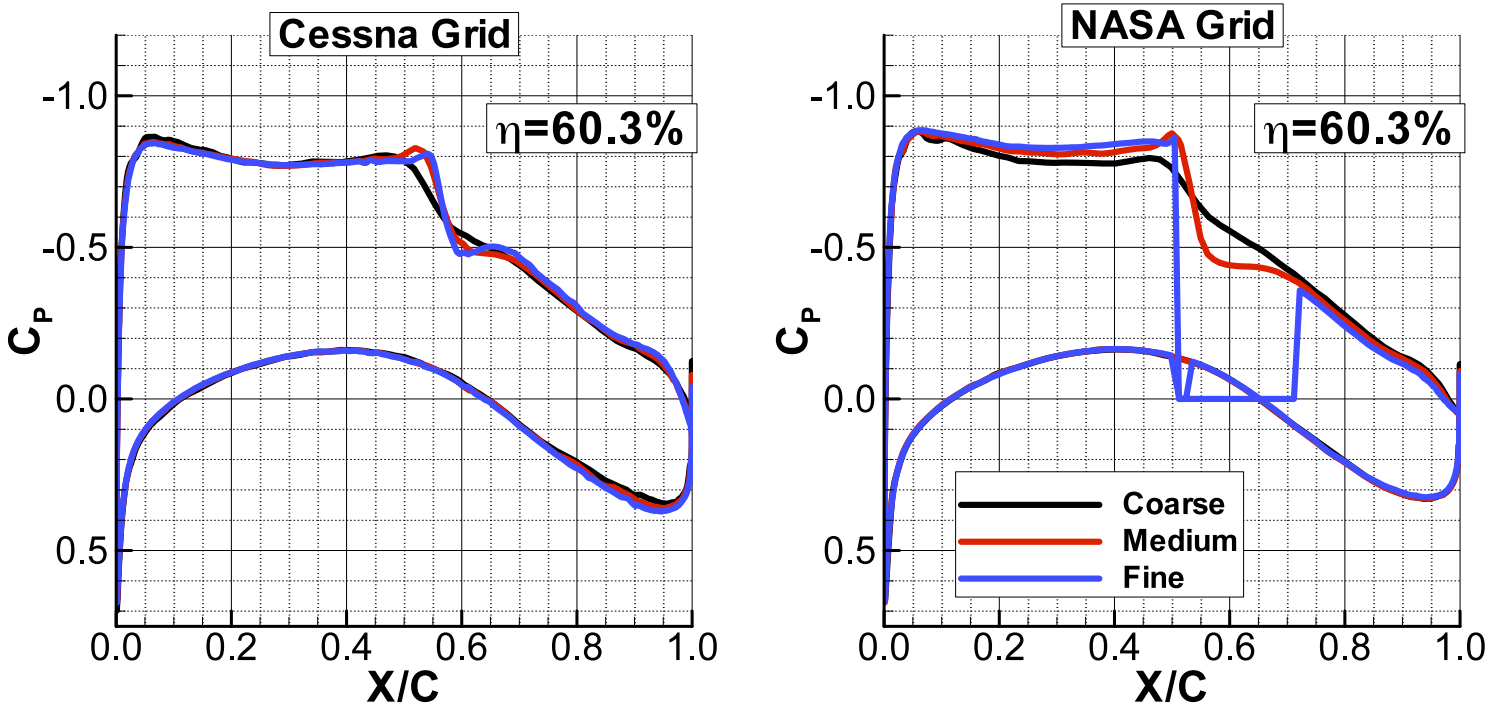

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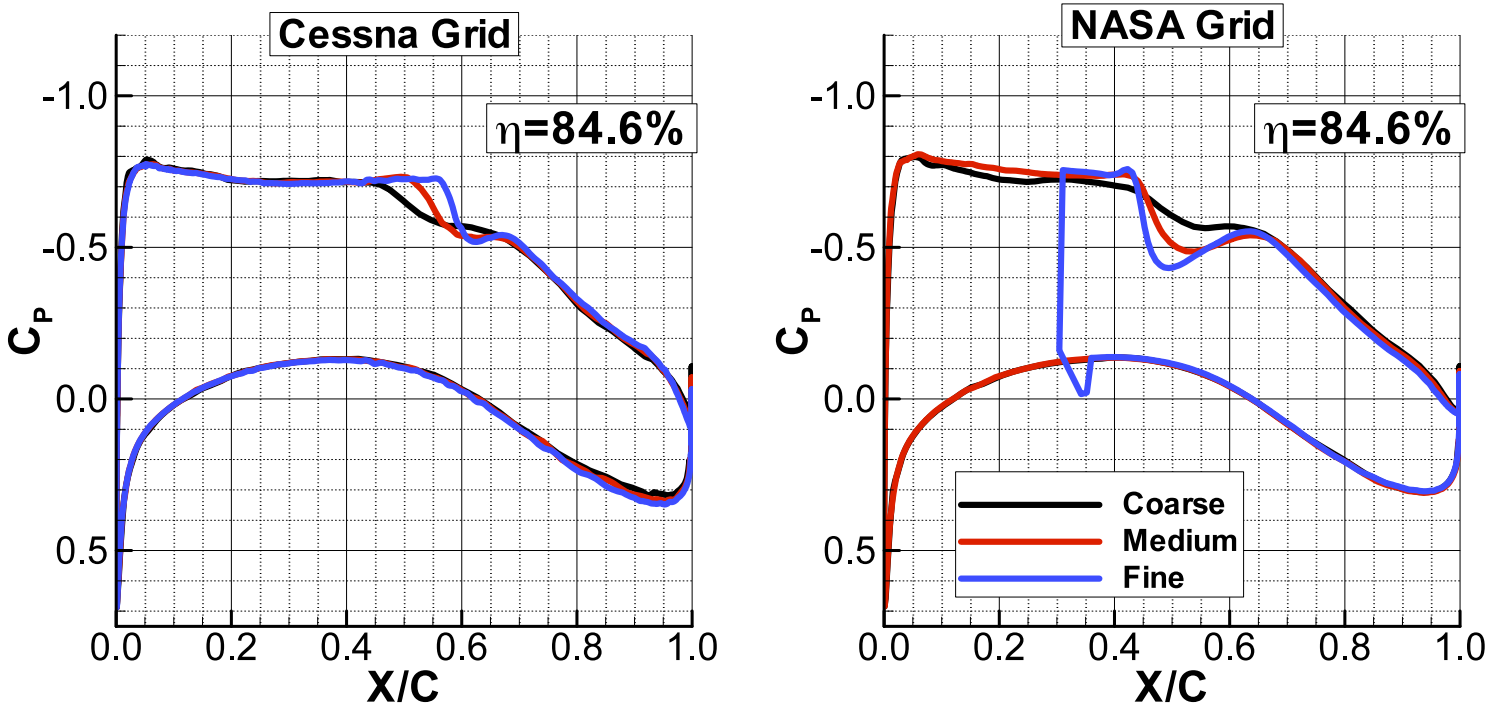

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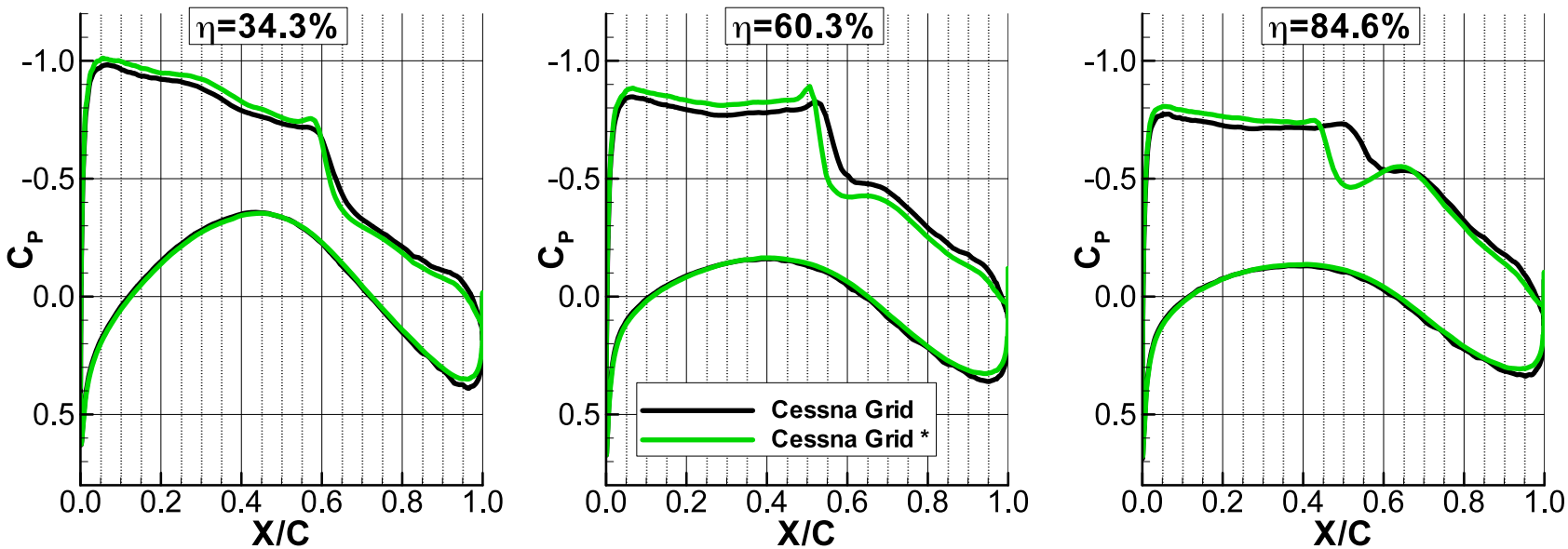
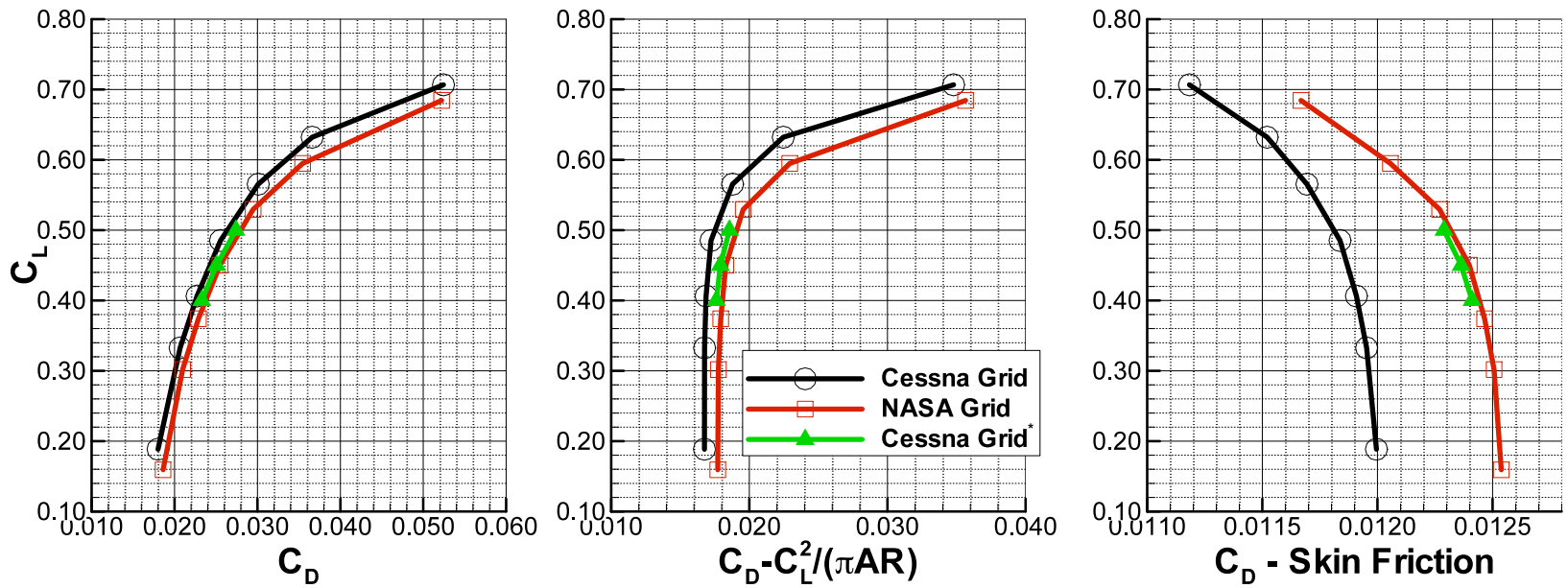
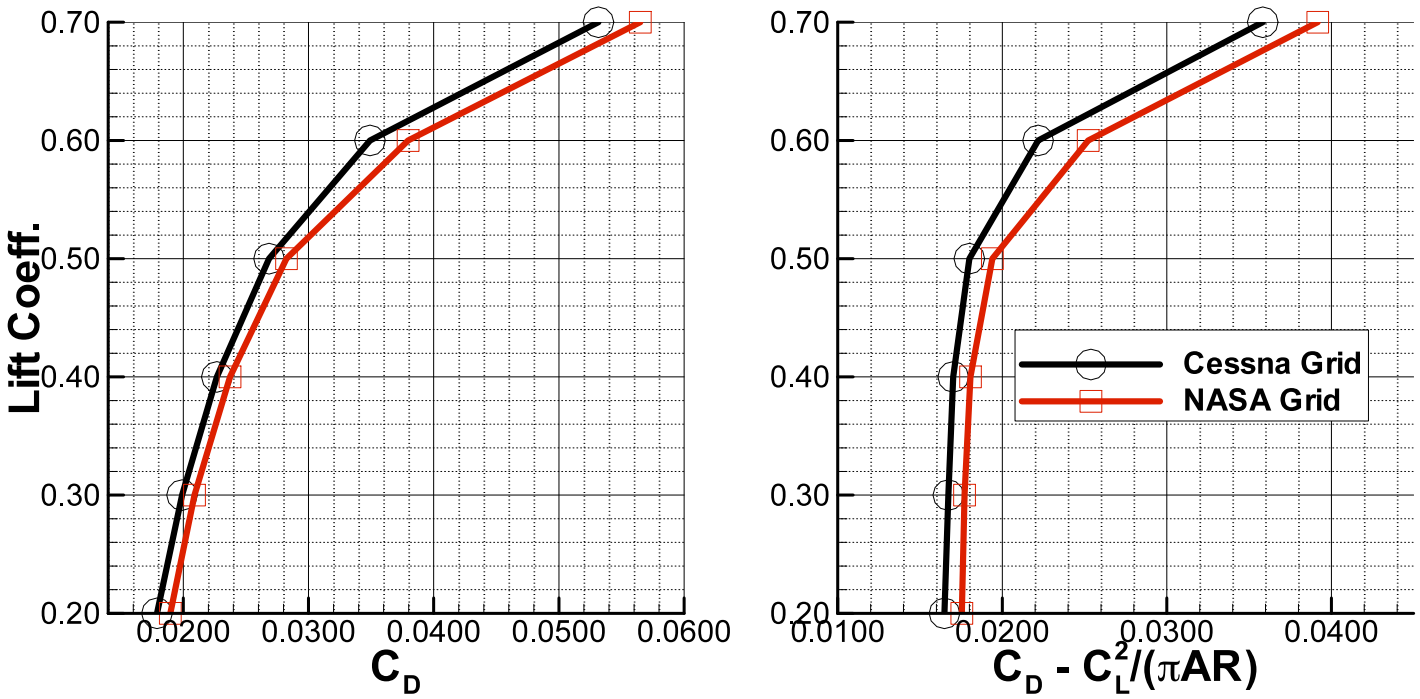
Effect of viscous growth rates on Cessna Medium Grid



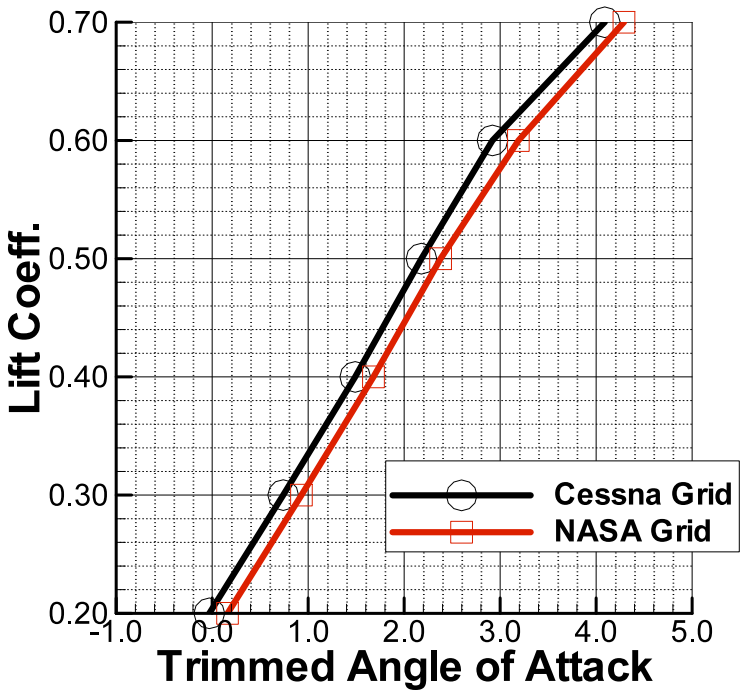
Case 1.2: iH=0 Drag Polars

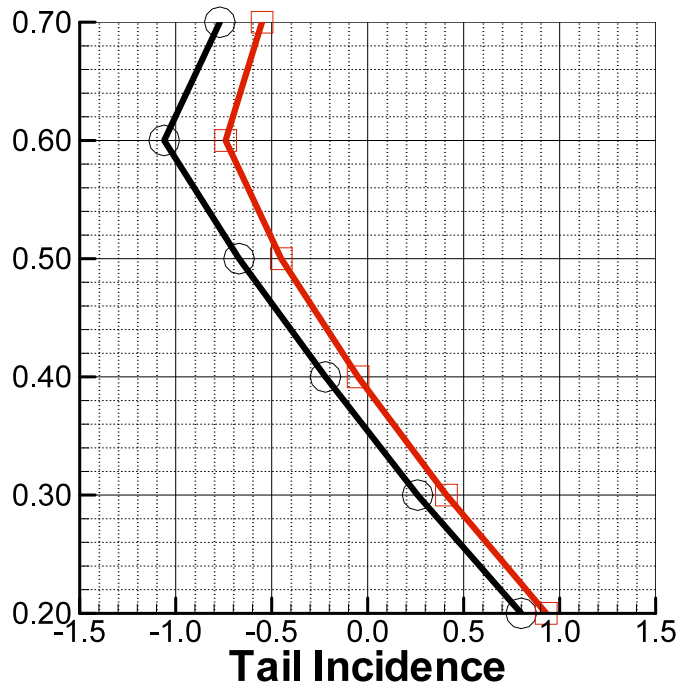


Case 1.2: Downwash Study – Trimmed Drag

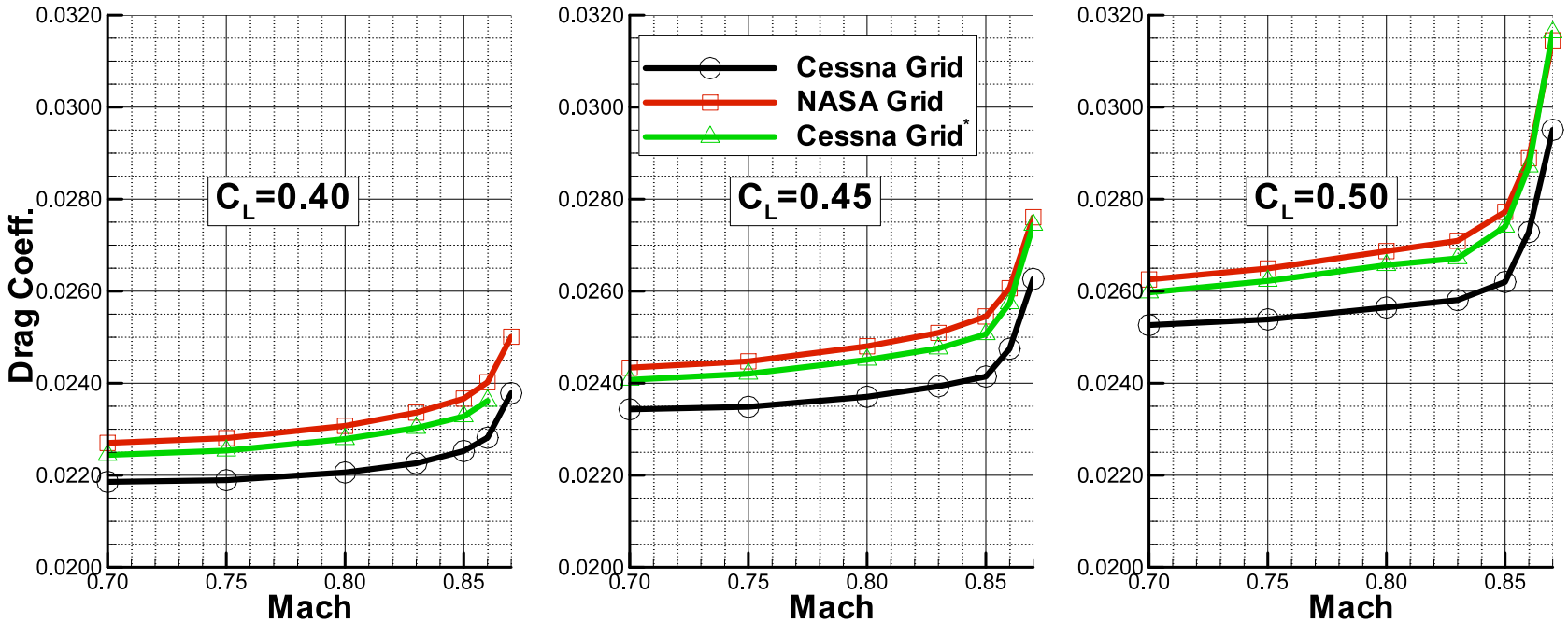


Case 1.2: Downwash Study – Trimmed angles

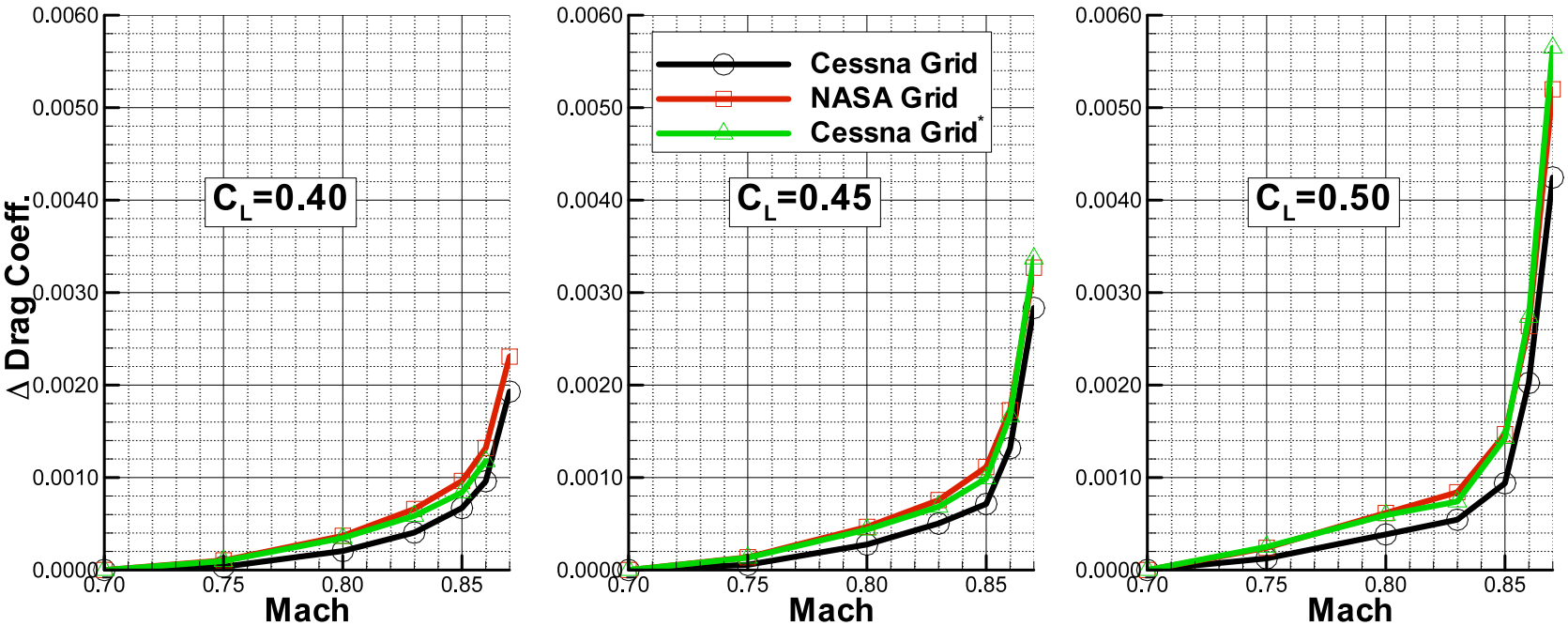




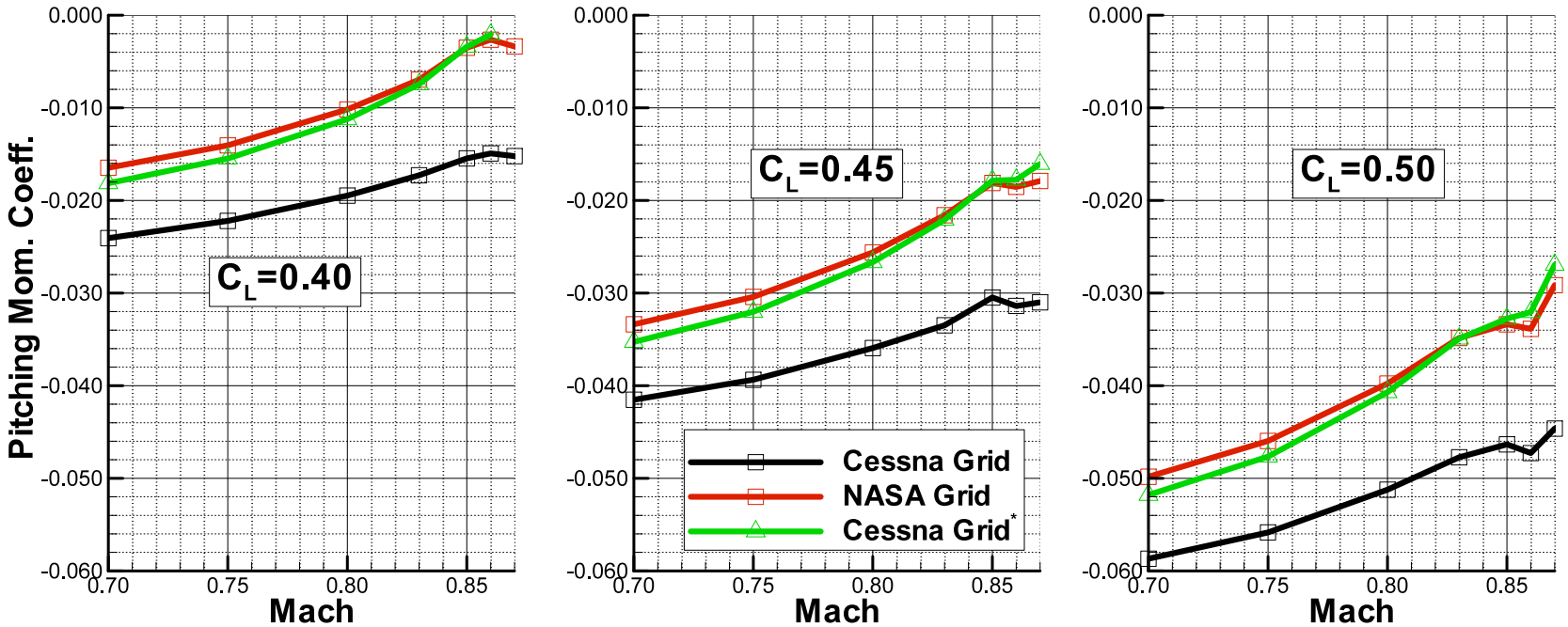
Case 2: Mach Sweep – Drag Coeffients



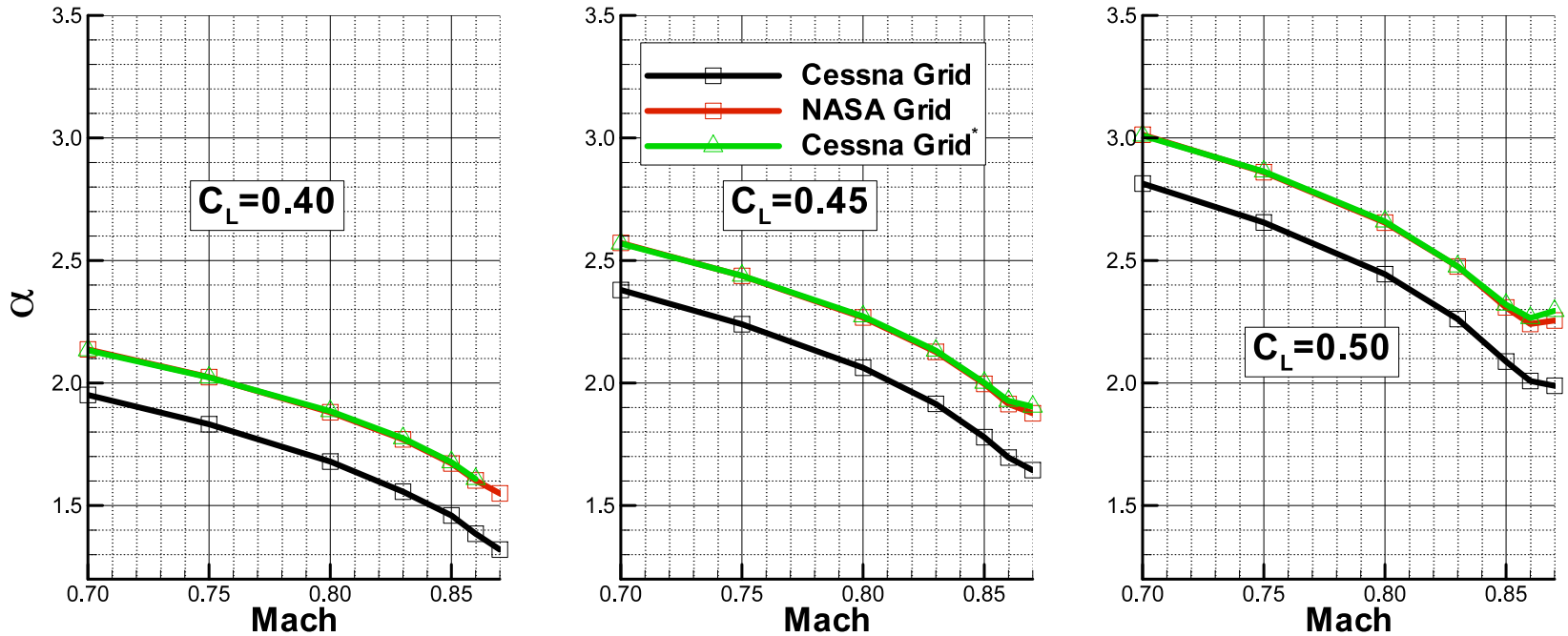
Case 2: Mach Sweep – Δ Drag Rise from M=0.70



Case 2: Mach Sweep – Pitching Moment Coeff.



Case 2: Mach Sweep – Angle of attack



Cessna
A Textron Company

Case 3: Re Number - Medium Grids

Grid	C_D Re=5x10^6	C_D Re=20x10^6	ΔC_D (counts)	ΔC_{Dp} (counts)	ΔC_{Dv} (counts)
Cessna	0.02621	0.02322	-29.9 (-11.4%)	-9.0	-20.9
NASA	0.02774	0.02451	-32.3 (11.6%)	-10.6	-21.7

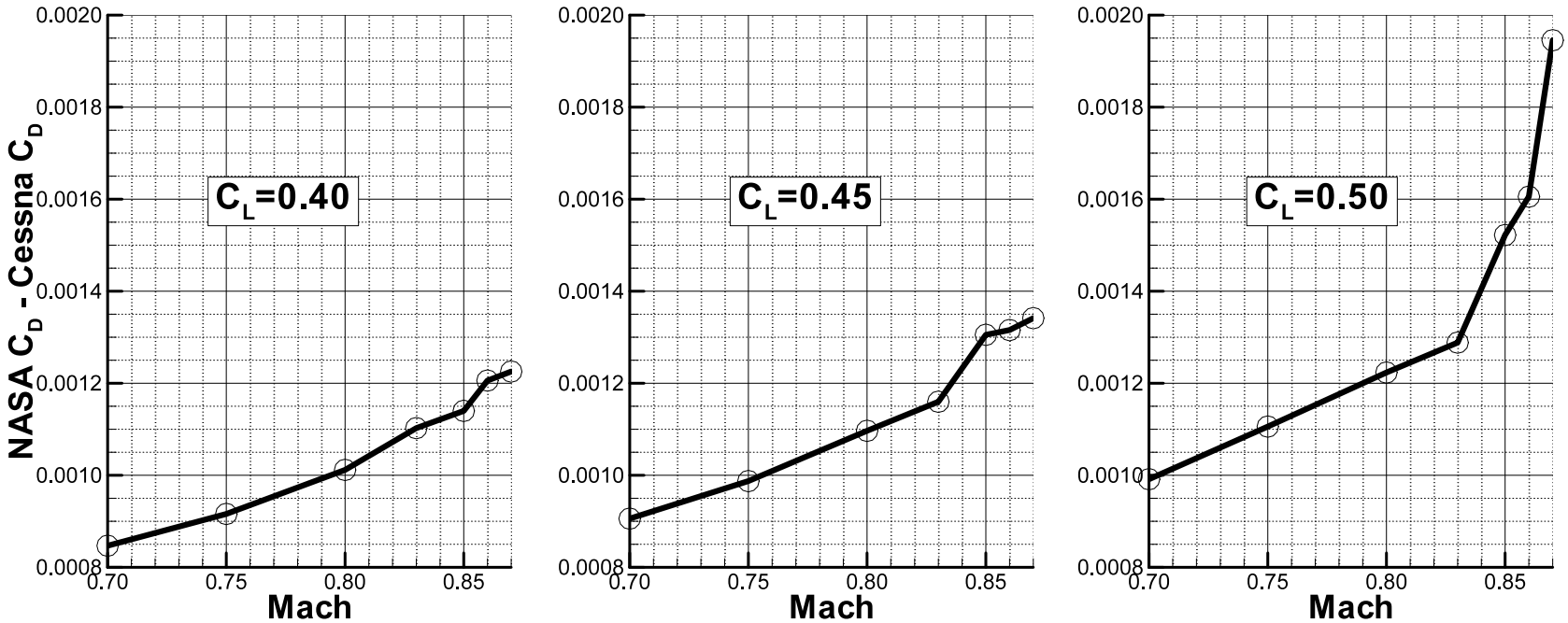
Grid	C_m Re=5x10^6	C_m Re=20x10^6	ΔC_m	$\Delta\alpha$
Cessna	-0.0464	-0.0539	-0.0075 (-16.2%)	-0.203
NASA	-0.0335	-0.0386	-0.0051 (-15.2%)	-0.183

Conclusions

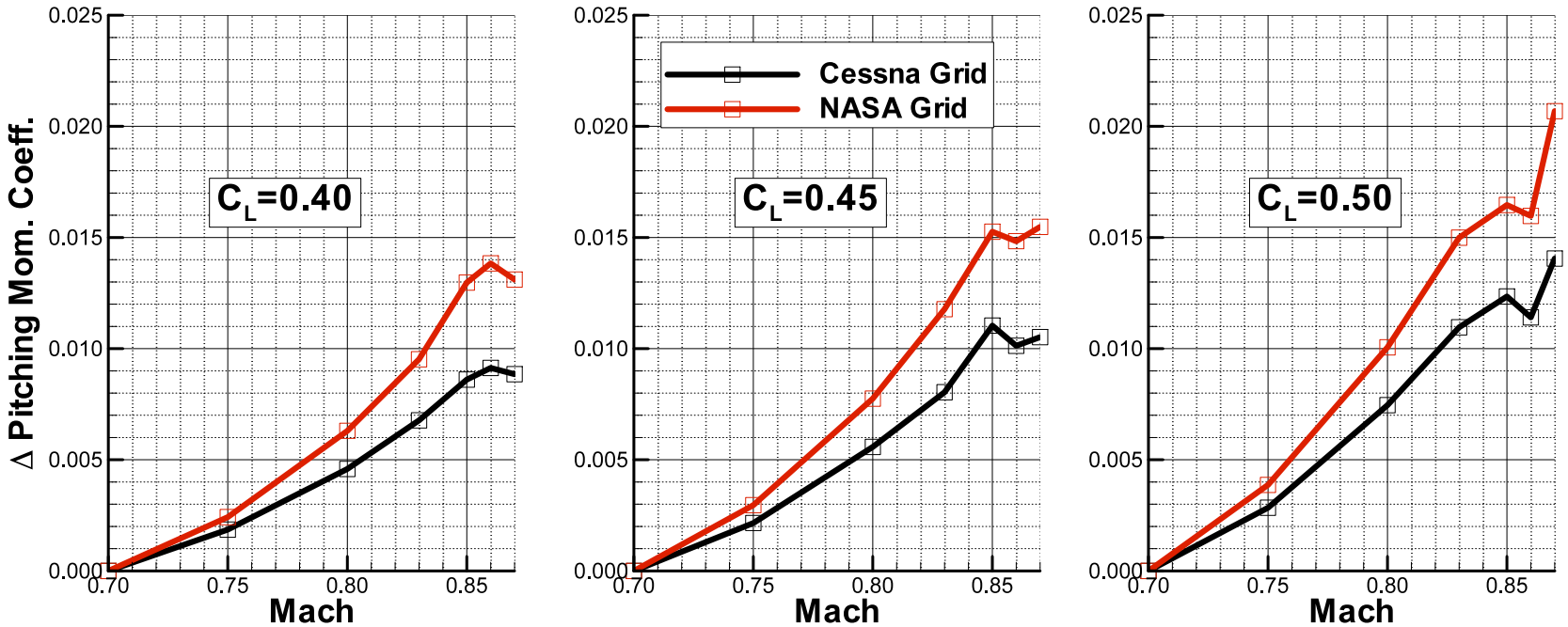
- **Substantial differences between Cessna and NASA grids**
  - **Lower skin friction drag with Cessna grid**
  - **Lower drag rise with Cessna grid**
  - **Stronger nose down pitching moment with Cessna grid**
  - **Shock location and aft loading change differently between Cessna and NASA grids**
- **Effects of viscous growth rate are larger than surface resolution effects**

EXTRA SLIDES

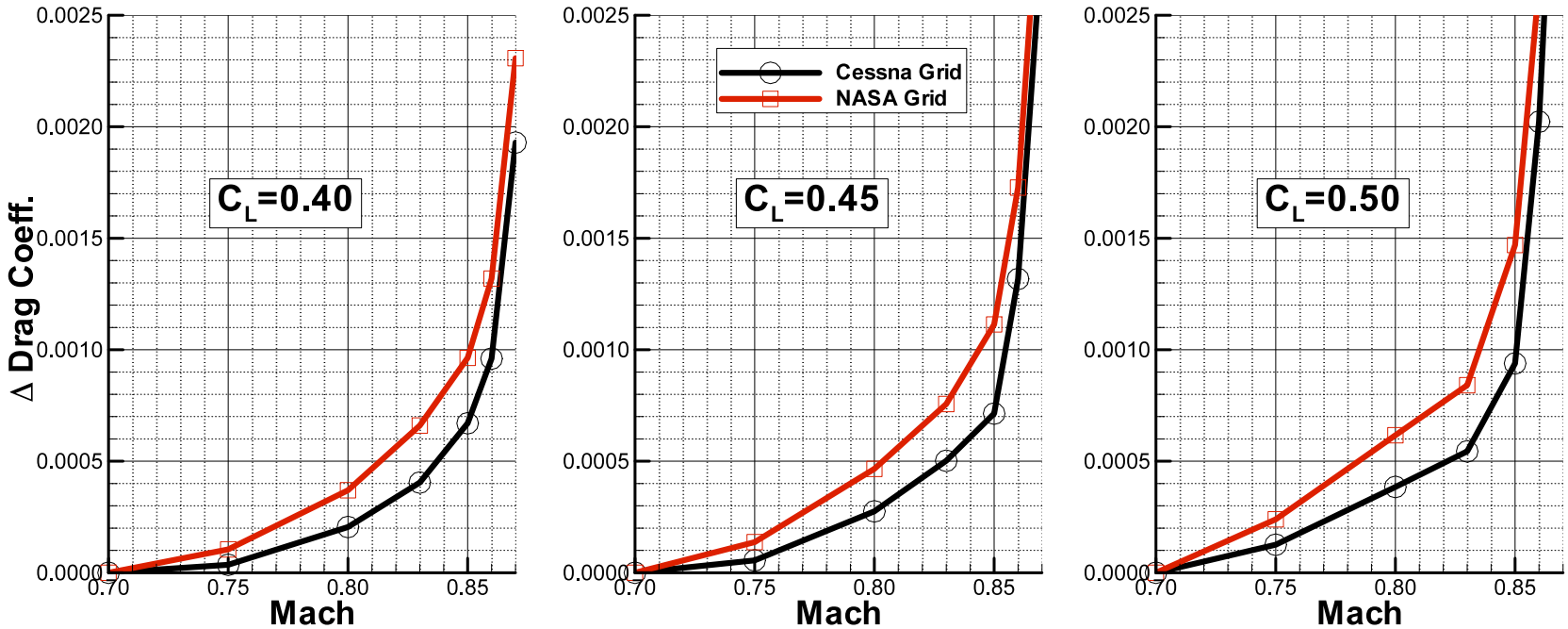
Mach Sweep – Δ Drag with Grid



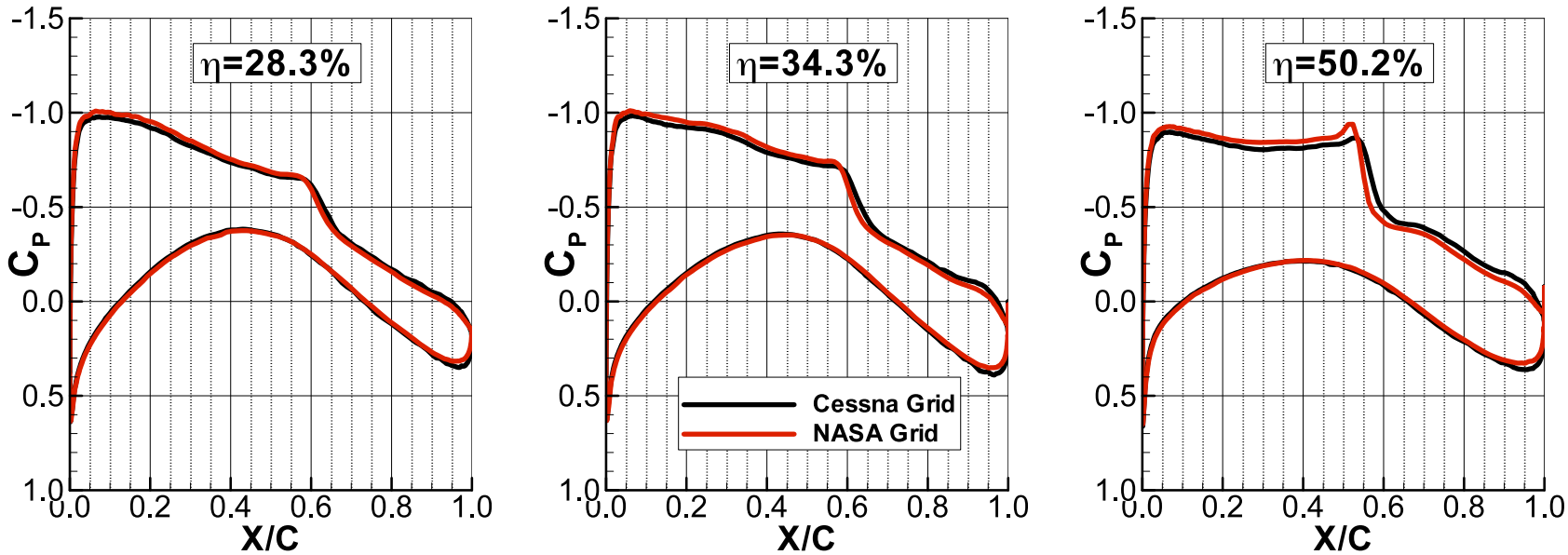
Mach Sweep – Δ Pitching Mom. Coeff.



Mach Sweep – Δ Drag Rise from M=0.70



Inboard wing C_P distributions, Med. grid



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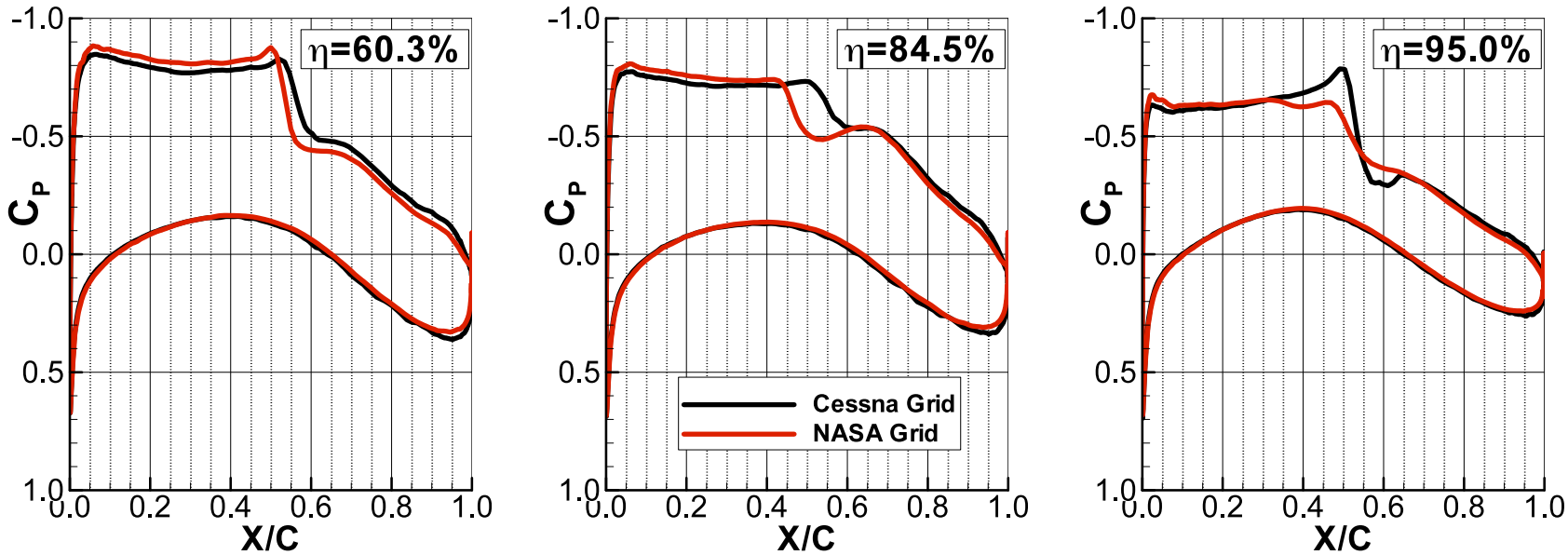
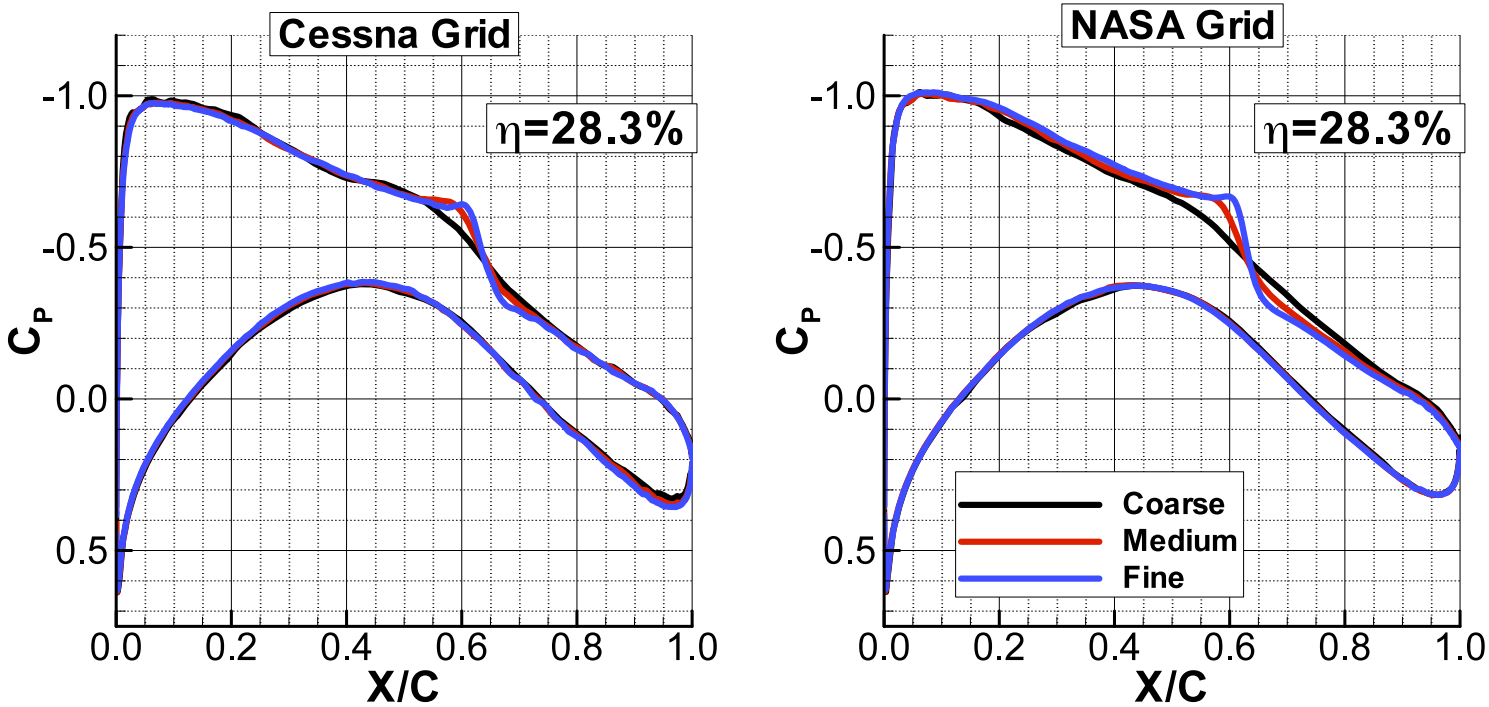
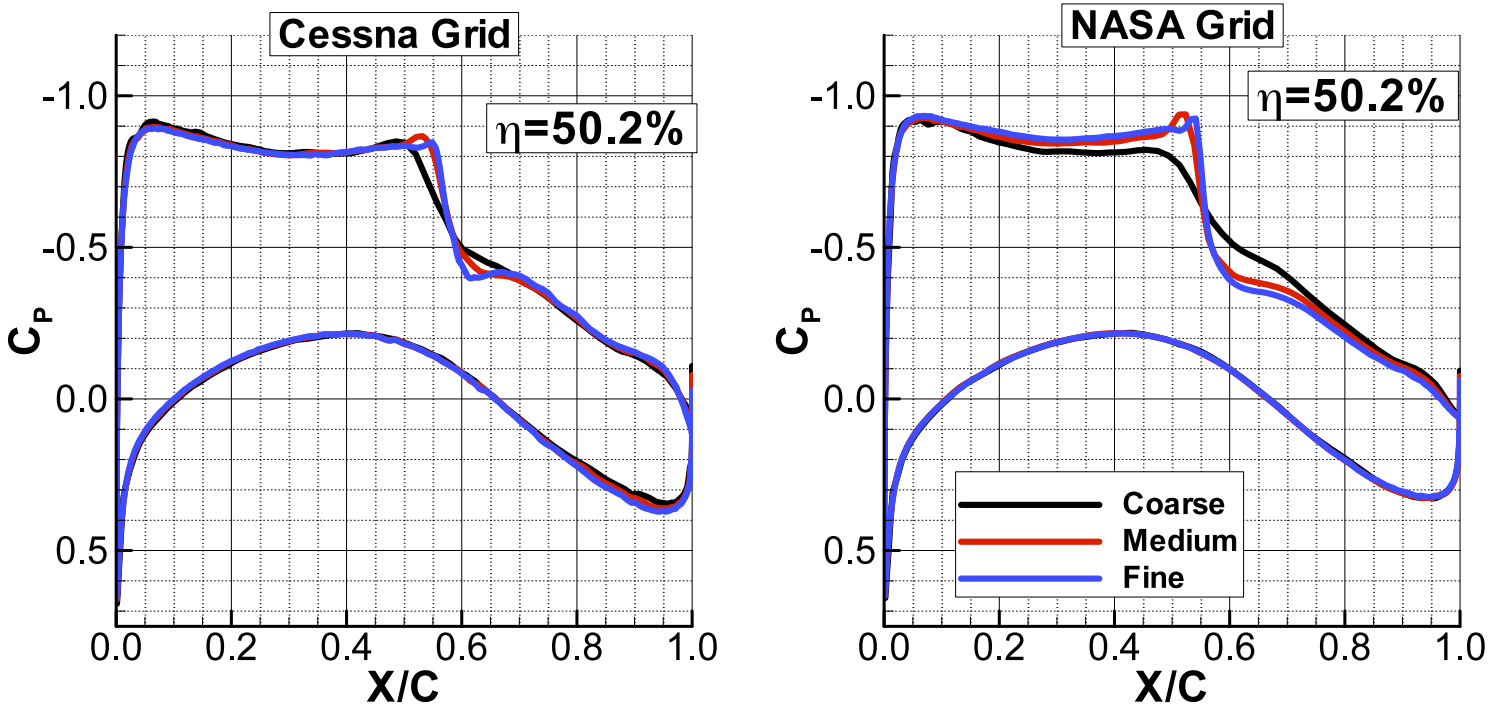


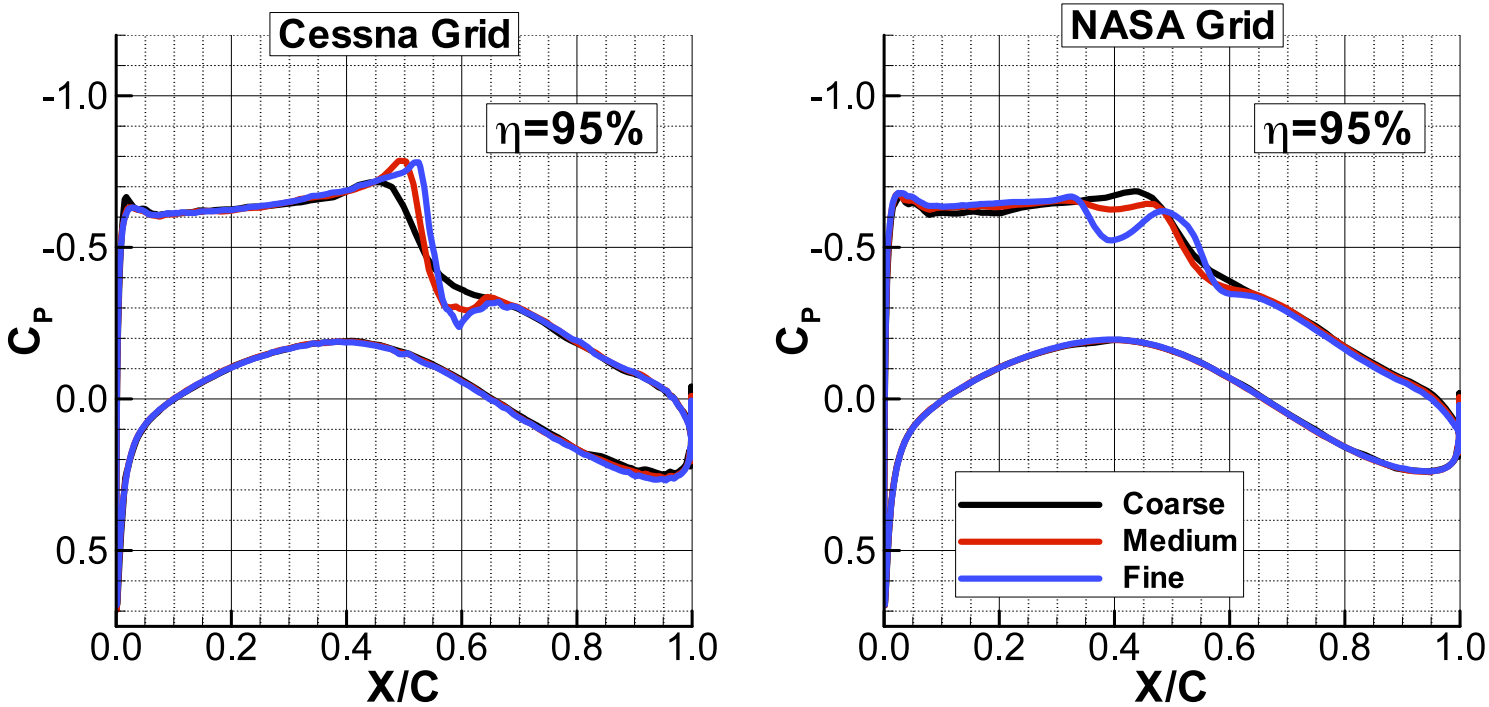
AIAA DPW4


Cessna Grid
η=28.3%
NASA Grid
η=28.3%
-1.0
-0.5
0.0
0.5
C_P
0.0
0.2
0.4
0.6
0.8
1.0
X/C
Coarse
Medium
Fine

AIAA DPW4


Cessna Grid
η=50.2%
-1.0
-0.5
0.0
0.5
C_P
0.0
0.2
0.4
0.6
0.8
1.0
X/C
NASA Grid
η=50.2%
Coarse
Medium
Fine

Case 1.1: C_P distribution: M=0.85, C_L=0.50, Re=5x10^6



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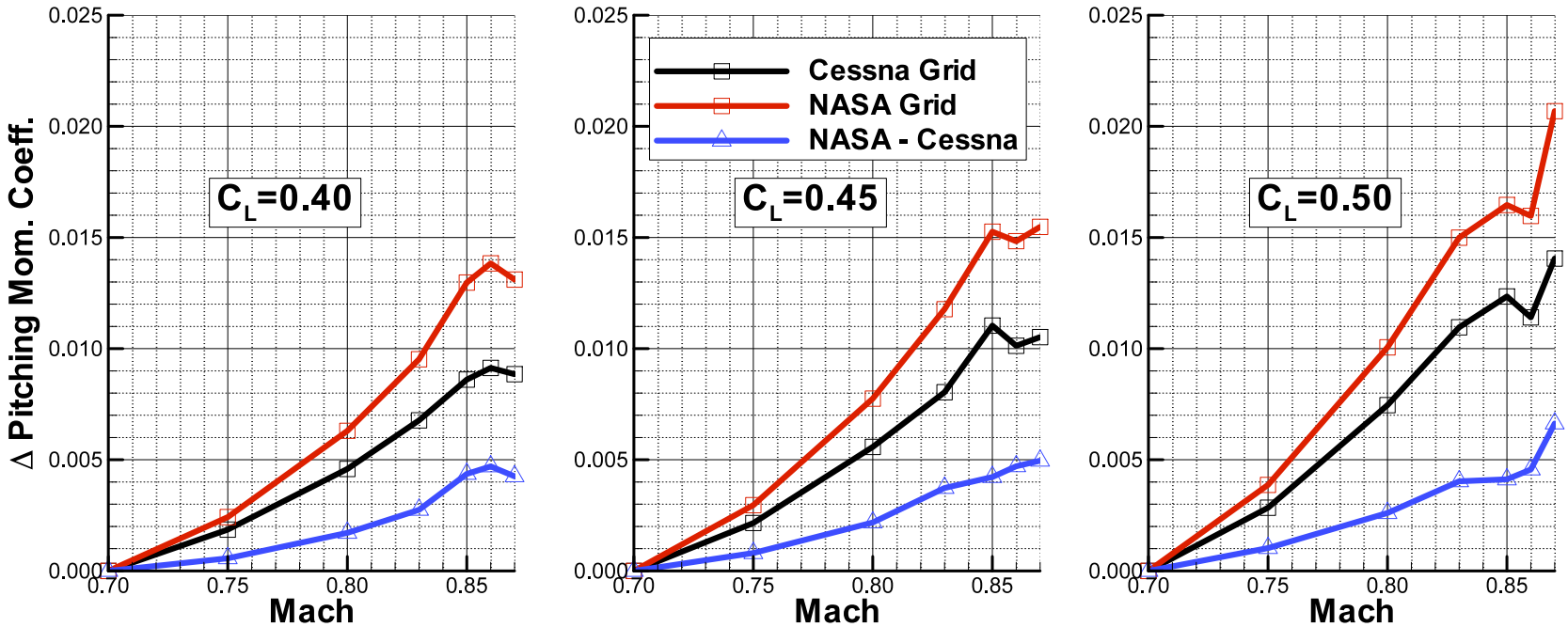
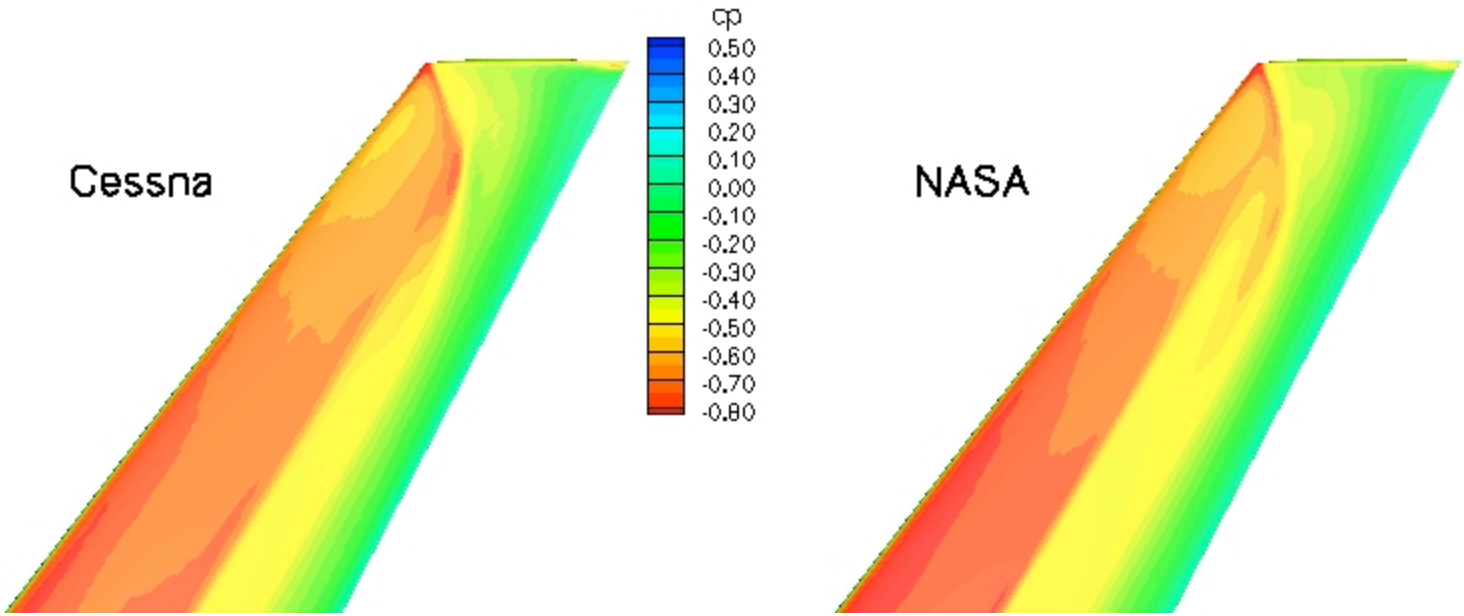
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