Assessment of an Unstructured Grid Navier-Stokes Code for Predicting Aircraft Performance

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Introduction

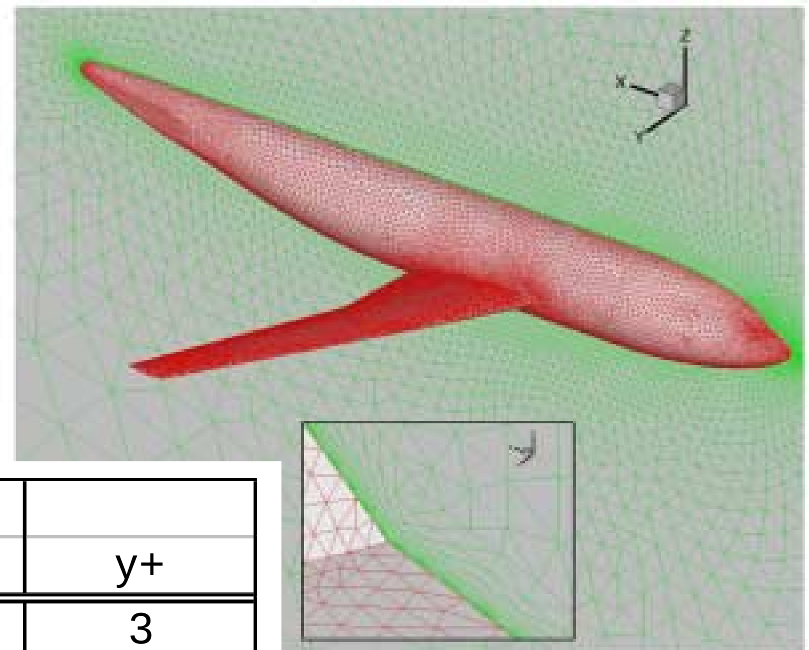
- **Purpose**
  - ***Assess LMAS tools drag prediction capabilities.***
  - ***Assess influence of select grid parameters on drag prediction.***
- **Outline**
  - ***CFD tools description.***
  - ***Grid description.***
  - ***Convergence criteria.***
  - ***Code performance / computer description.***
  - ***CFD results.***
- **Summary / Conclusions**

Aerodynamics Tools Description

- **Grid Generator - GRIDTOOL / VGRID3D**
  - ***NASA LaRC developed***
  - ***Tetrahedral based unstructured grids***
    - Advancing layers to resolve boundary layer
    - Minimizes grid generation time
- **Flow Solver - USM3Dns**
  - ***NASA LaRC developed***
  - ***Euler and Navier-Stokes***
    - Cell based
    - Implicit
  - ***Spalart-Allmaras turbulence model***
    - Wall function
  - ***Fully turbulent***
- **LM Previous Experience**
  - ***Extensively utilized - main CFD code for over 3 years***
  - ***Excellent correlation with wind tunnel and flight data***

Grids Description

- ***Baseline FV*** **(Full Viscous) - Workshop Provided**
  - ***Solutions generated but not reported***
  - ***USM3D bug with force/moment calculation (FV only)***
- ***Baseline WF*** **(Wall Function) - NASA LaRC Provided**
- ***MOD 1 WF*** **- LMAC Developed**
  - ***Similar to Baseline WF***
- ***MOD 2 WF*** **- LMAC Developed**
  - ***Refined wing LE and fuselage nose***
  - ***Otherwise same as MOD 1 WF***
- ***MOD 3 WF*** **- LMAC Developed**
  - ***Same as MOD 2 WF with reduced y+***

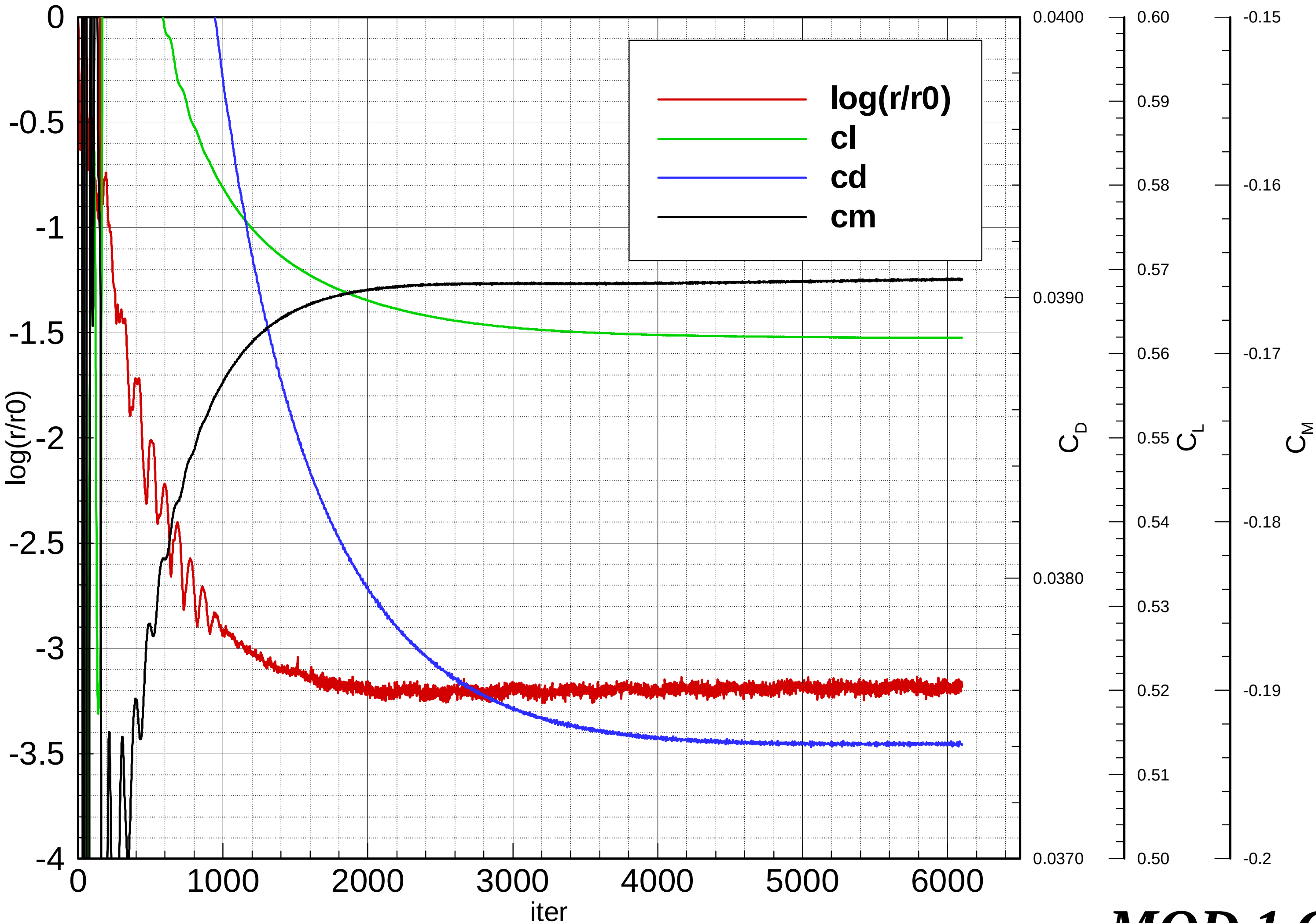


Mod 2 WF GRID

Title	Number of Layers	Volume Cells	Surface Nodes	y+
Baseline FV	35	2.74E+06	23290	3
Baseline WF	11	2.39E+06	25175	50
MOD 1 WF	11	3.08E+06	32716	40
MOD 2 WF	11	3.61E+06	40371	40
MOD 3 WF	12	3.93E+06	40789	20

Convergence Criteria

Alpha=0 degrees, M=0.75, Re=3.0x10^6



MOD 1 GRID

Code Performance / Beowulf Cluster

Code Performance

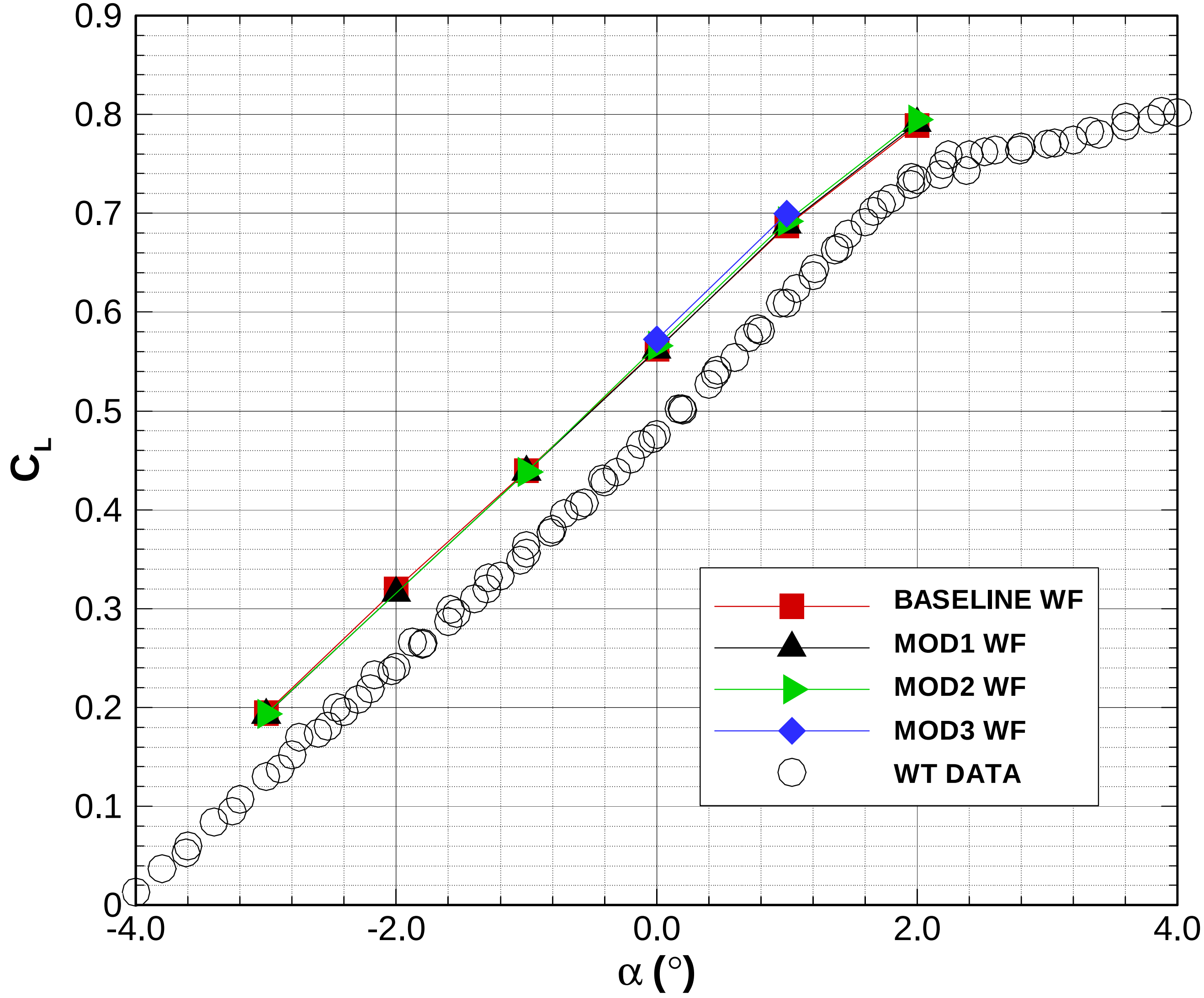
- **Baseline WF Grid (5,000 iters)**
  - ***2.39×10^6 Cells***
- **40 processors / 20 nodes**
- **CPU Time: 720 hours**
- **Wall Clock Time: 20.0 hours**
- **Memory Requirements: 168 words/cell**

Cluster Description

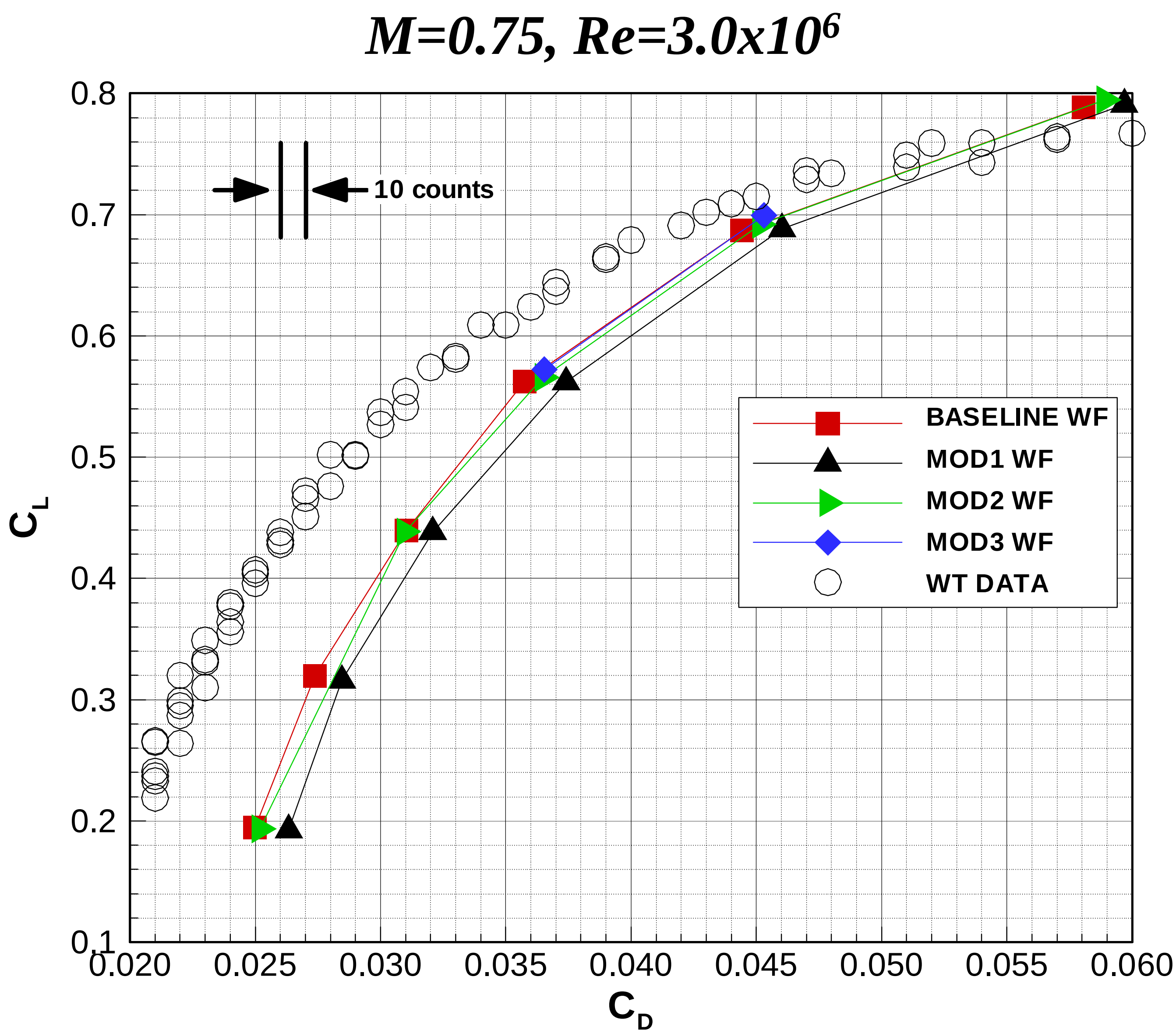
- **64 Node Cluster**
  - ***Dual Intel PIII 850 Mhz Processors***
  - ***128 Total Processors***
  - ***768 MB PC100 ECC RAM / Node***
- **2 Clusters**

USM3D Predictions on the DLR-F4 Wing/Body Configuration

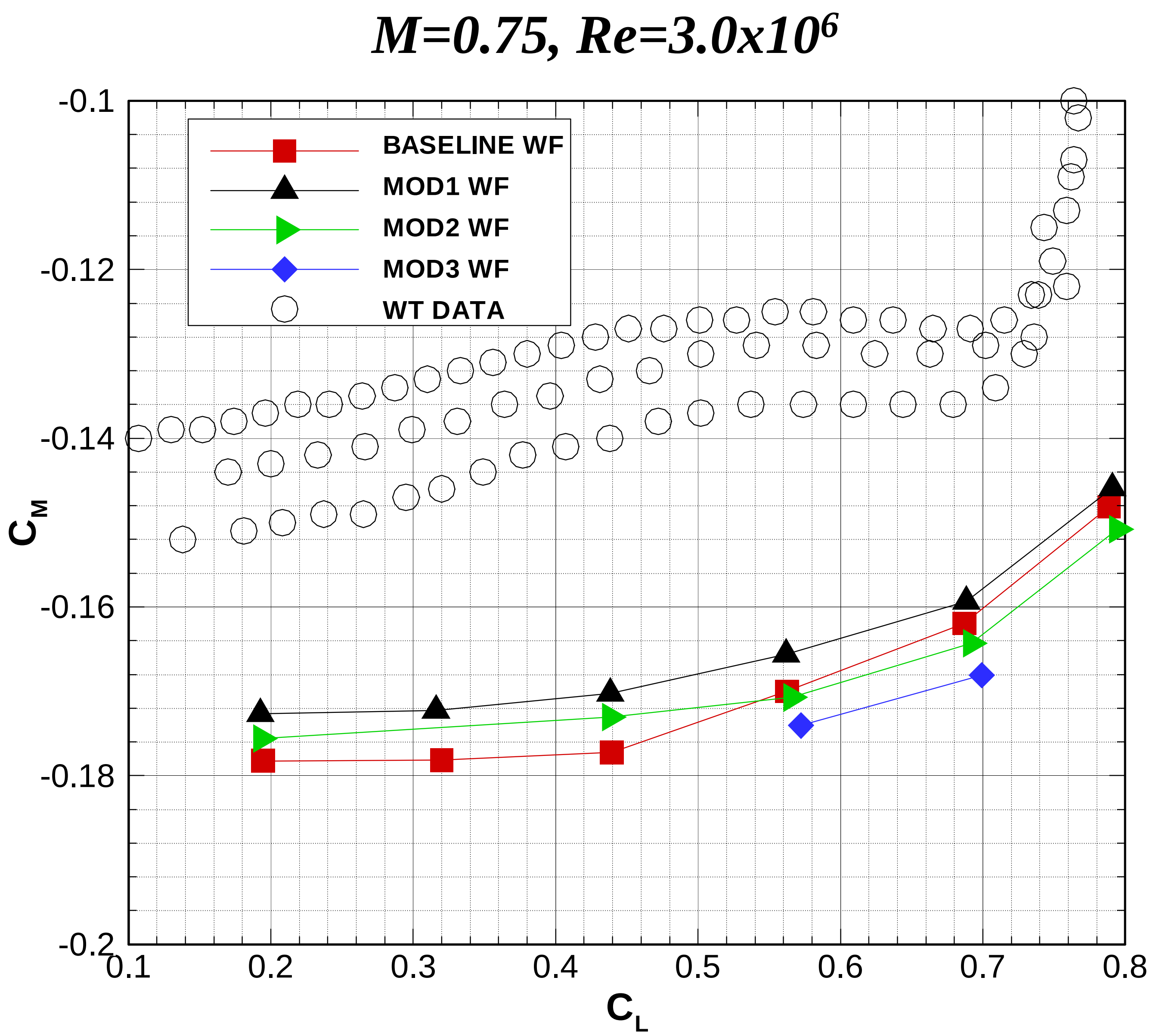
$M=0.75$, $Re=3.0x10^6$



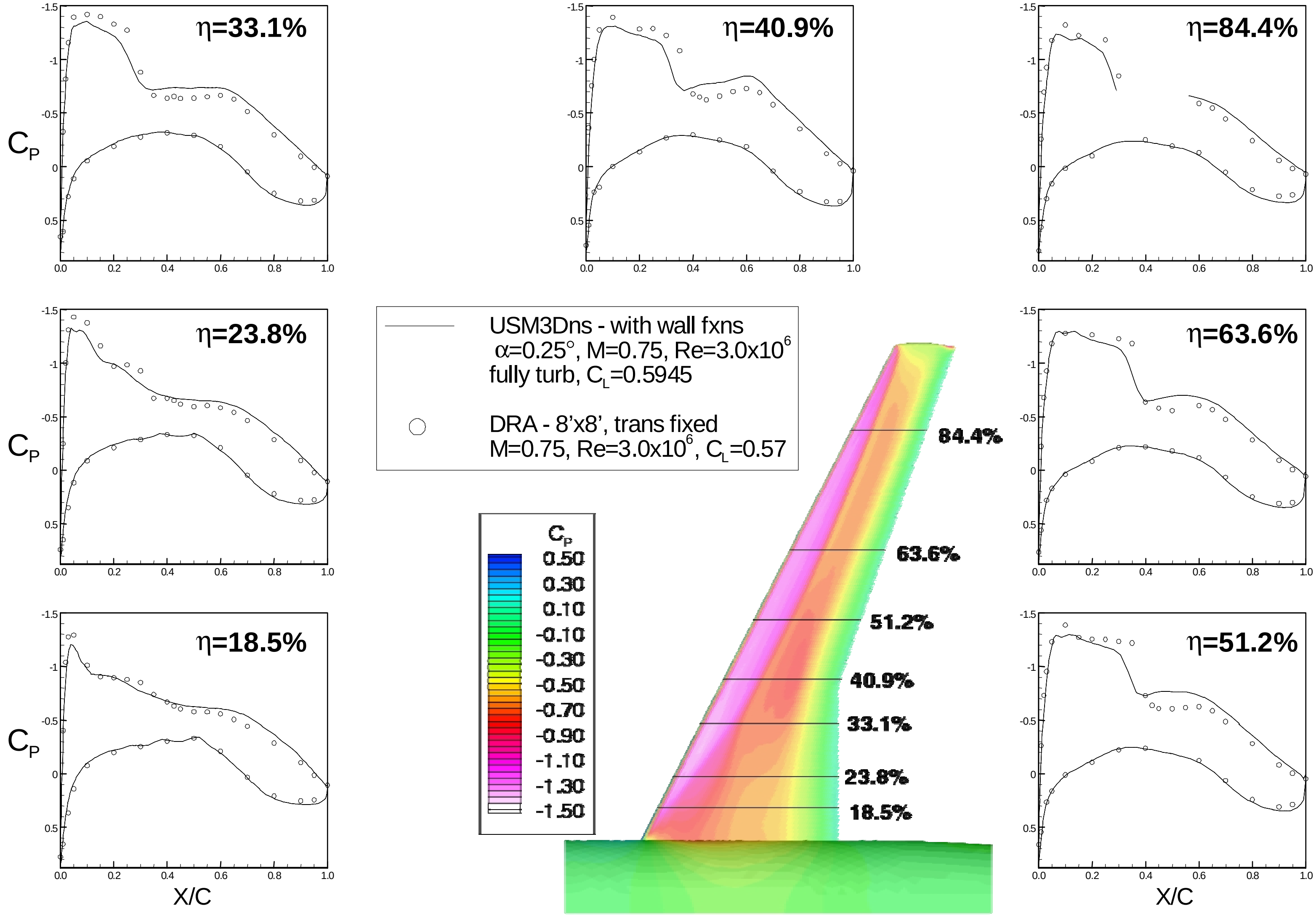
USM3D Predictions on the DLR-F4 Wing/Body Configuration



USM3D Predictions on the DLR-F4 Wing/Body Configuration



USM3D Predicted Wing Surface Pressures on the DLR-F4 Wing/Body Configuration



Summary / Conclusions

- **Assessed USM3Dns drag prediction capabilities**
  - ***Evaluated baseline wall function grid***
  - ***Evaluated 3 LMAS generated grids***
    - Investigated wing leading edge and fuselage nose grid refinement effects
    - Investigated initial viscous grid spacing effects
    - Not considered optimal or drag converged grids
  - ***Not able to report on full viscous drag results***
- **Grid refinement effects**
  - ***Minimal CL impact***
  - ***~5% drag reduction***
    - Not drag converged
  - ***Slight CM impact***
- **Initial viscous grid spacing effects**
  - ***Minimal CL and CD impact***
  - ***Slight CM impact***
  - ***y+ of 40 or 50 sufficient for wall function results with ~8 cells across BL***
- **Future work**
  - ***Evaluate latest USM3Dns recommendations from NASA LaRC***