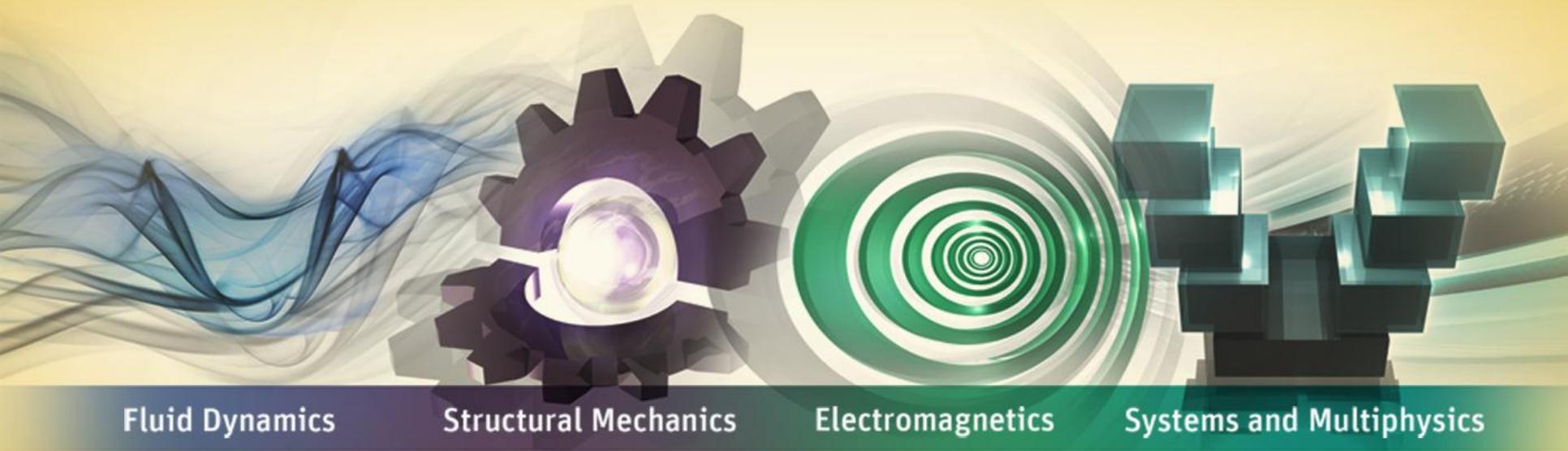


# ANSYS CFD Results for the AIAA 2<sup>nd</sup> High Lift Prediction Workshop



Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

**Bala Sasanapuri**

Sr. Technology Specialist

Pune, India

**Robin Steed**

Sr. Software Developer

Waterloo, Canada

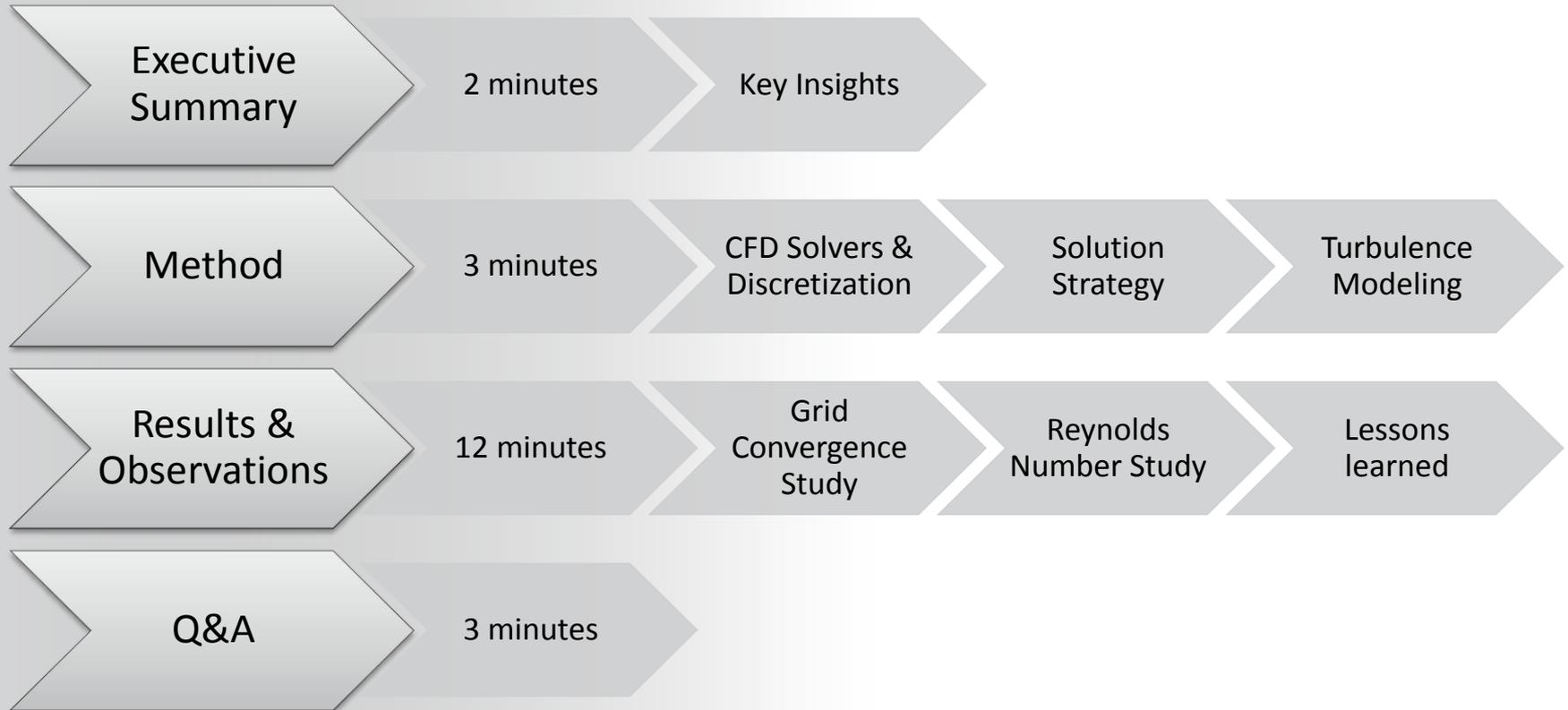
**Vijay Veera**

Technical Services Engineer

Sheffield, UK

- **Team *HP***
  - Don Mize
  - Imran Aziz Ahmad

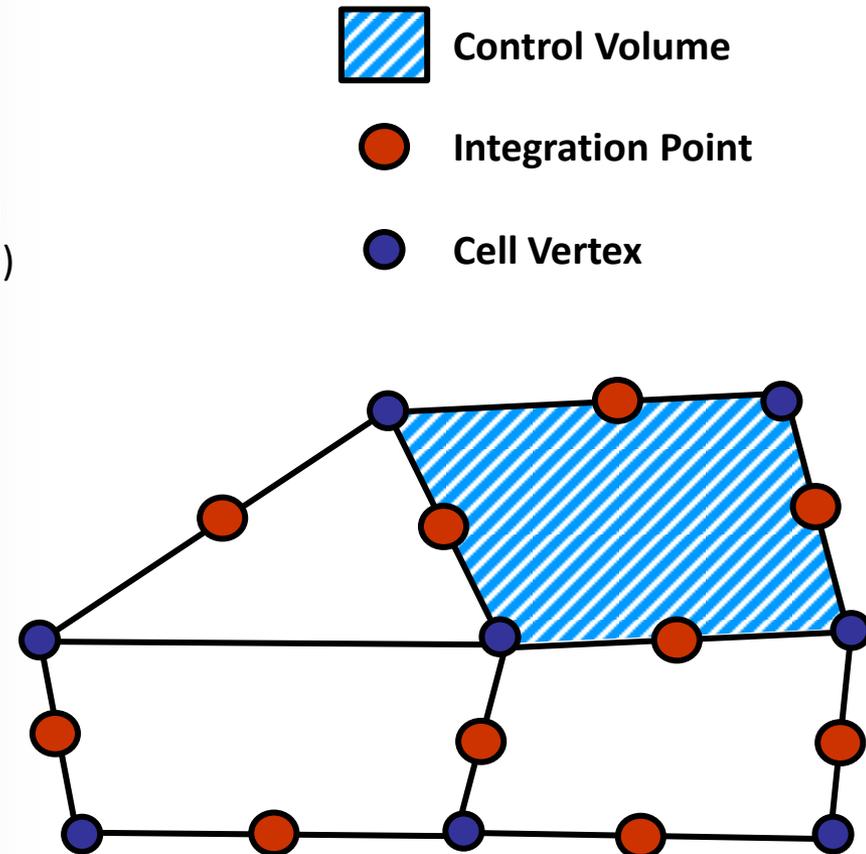




# Key Insights

- **Excellent prediction of trends and accurate force/moment predictions with hybrid meshes in CFX and hybrid/poly meshes in Fluent**
- **Poly meshes improved the accuracy for Fluent**
- **Poly meshes have shown speed up of 2 to 3 times compared to hybrid meshes**
- **SST k-w model has shown reasonably good results for the low Re case**
  - Missing fairings in the simulation geometry might have caused some discrepancy
  - Further tests will be done with fairings included and by using SST transition model

- **Mesh:**
  - Unstructured, hex, tet, wedge, pyramid, poly elements
  - Cell centered control volume
  - Co-located c.v.'s for all equation types
- **Numerics:**
  - Density Based and Pressure Based Solvers
  - Default 2<sup>nd</sup> order space and time discretization
  - Coupled algebraic multigrid linear solver (AMG)
- **Physics:**
  - Wide range of physics supported
  - Advanced turbulence models
  - Eulerian & Lagrangian multiphase
  - Combustion, radiation,....
- **Parallel:**
  - Domain decomposition
  - MeTiS & other partitioners



- **Mesh:**

- Unstructured, hex, tet, wedge, pyramid elements
- CVFEM: c.v.'s defined by element mesh dual (polyhedral volumes)
- Co-located c.v.'s for all equation types

- **Numerics:**

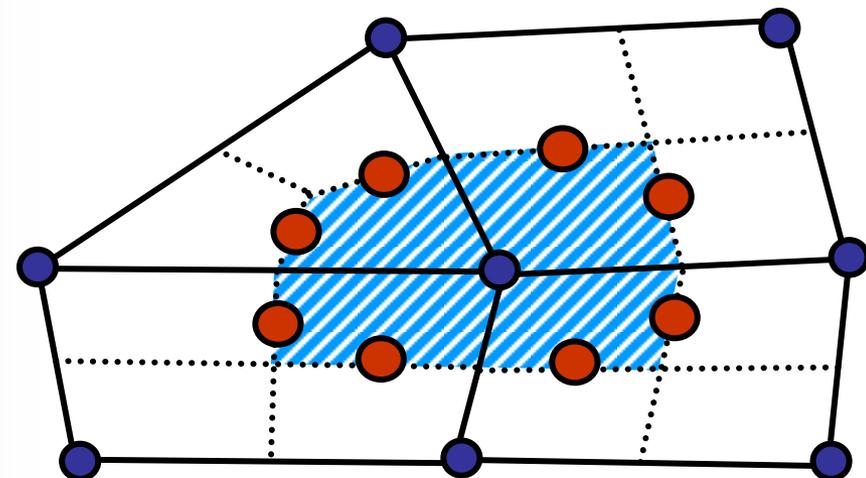
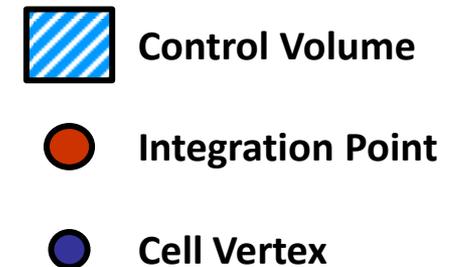
- Default 2<sup>nd</sup> order space and time discretization
- Implicit pressure based all speed method
- Coupled algebraic multigrid linear solver (AMG)

- **Physics:**

- Wide range of physics supported
- Advanced turbulence models
- Advanced turbomachinery models
- Eulerian & Lagrangian multiphase
- Combustion, radiation,....

- **Parallel:**

- Domain decomposition
- MeTiS & other partitioners

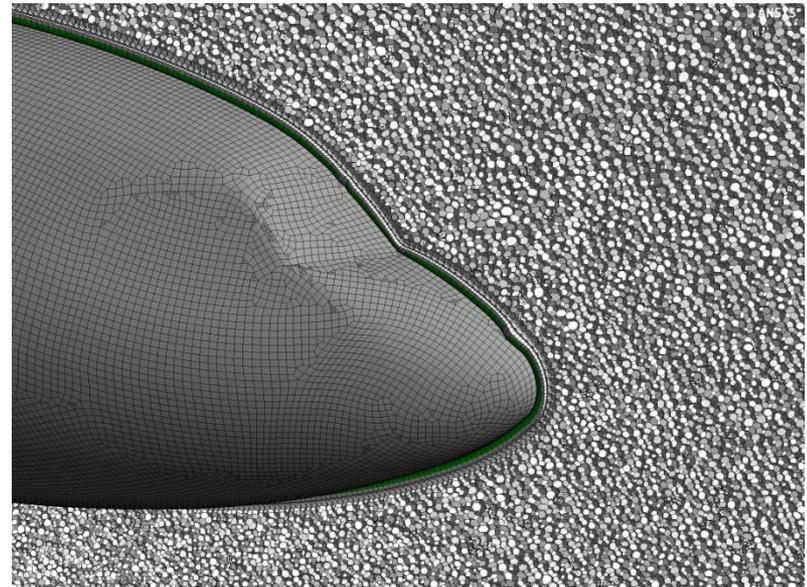
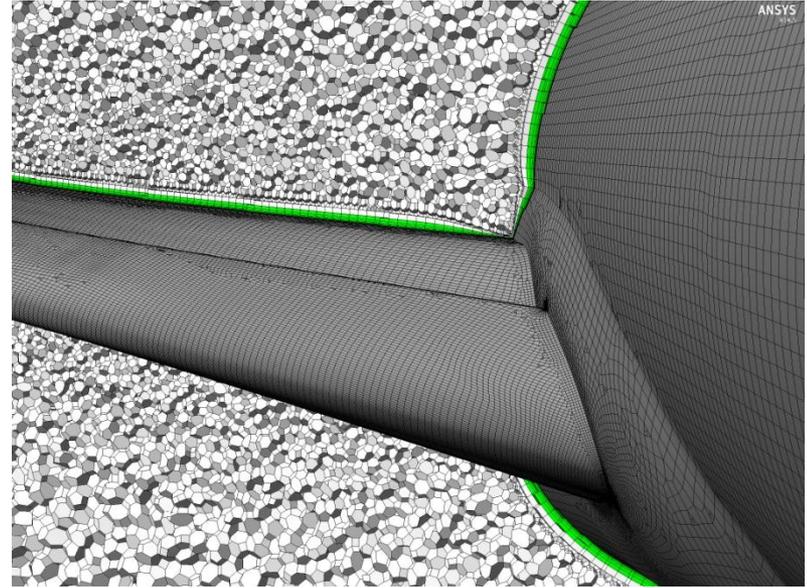
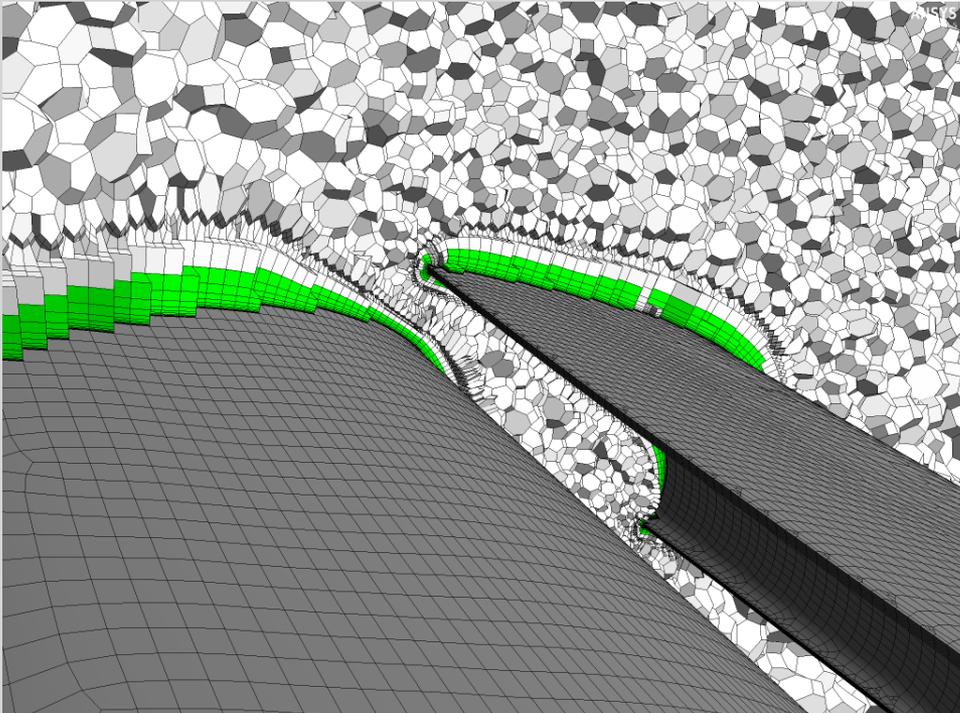


# Solution Strategy

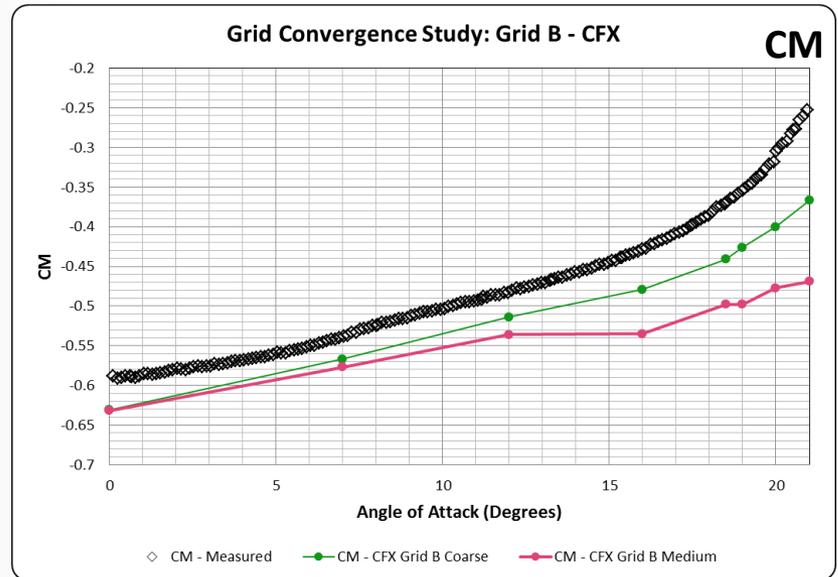
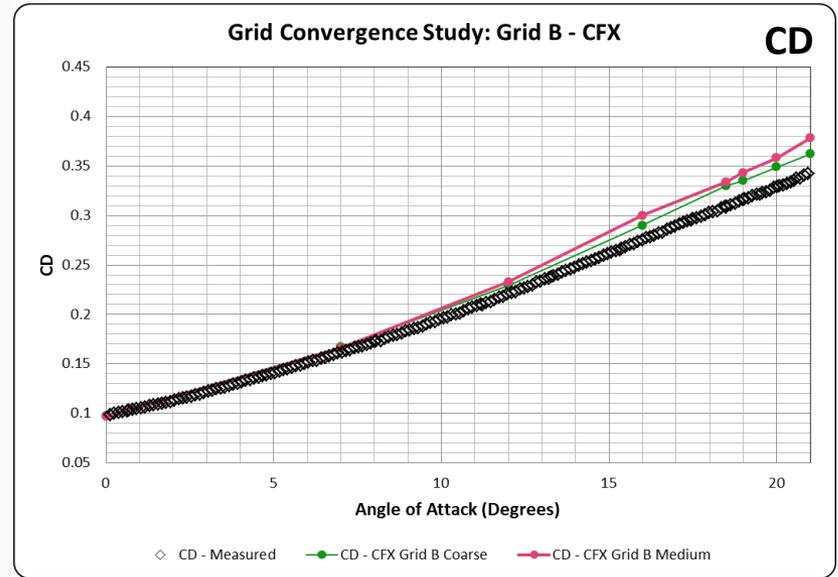
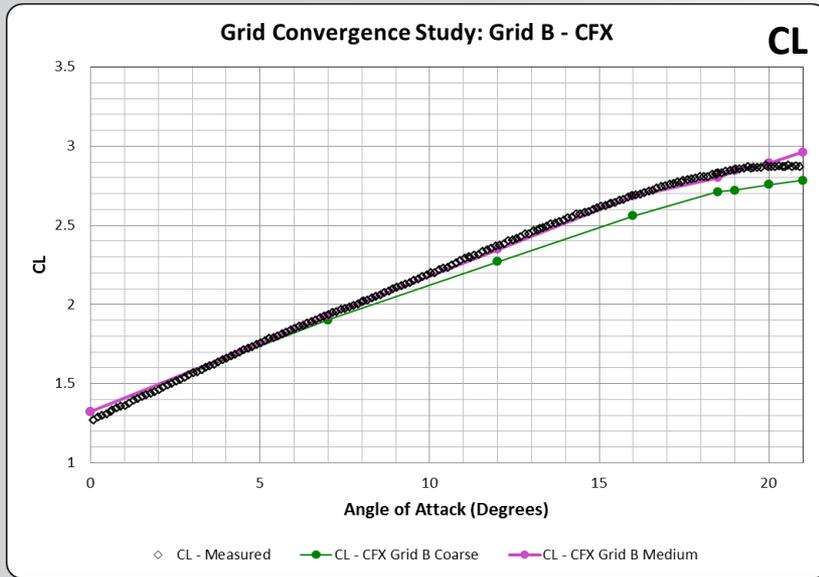
- **Pressure Based Coupled Solver**
- **Pseudo Transient Solution method**
- **SST k-w Turbulence Model**
- **Second Order Discretization for all equations**
- **Mean Aerodynamic Cord based time step**

# Grid Convergence Study: Meshes

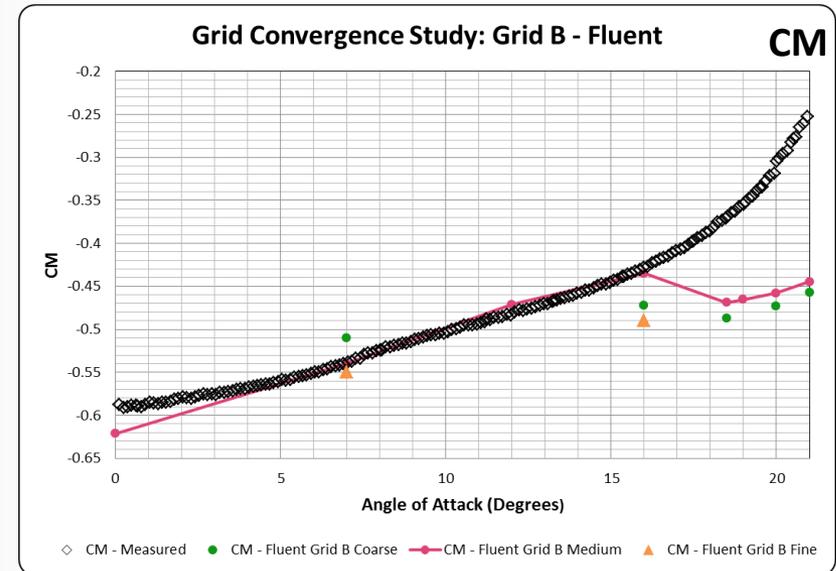
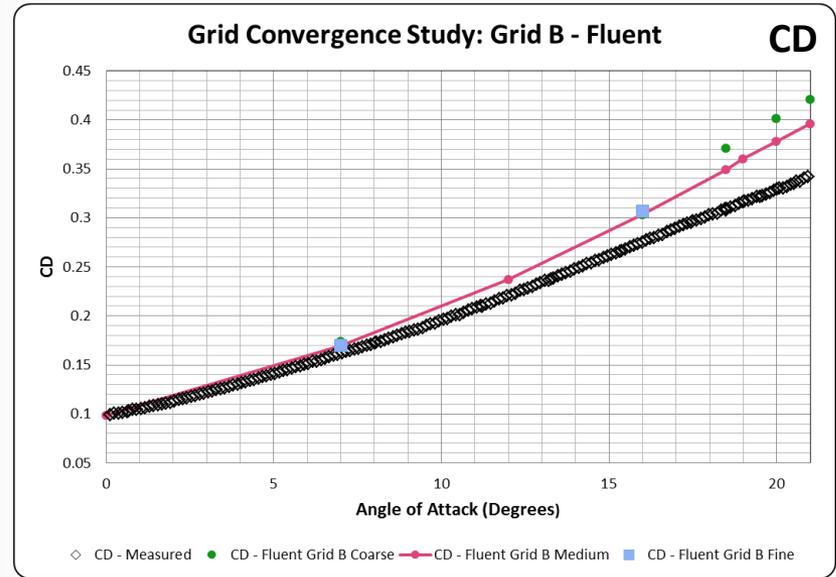
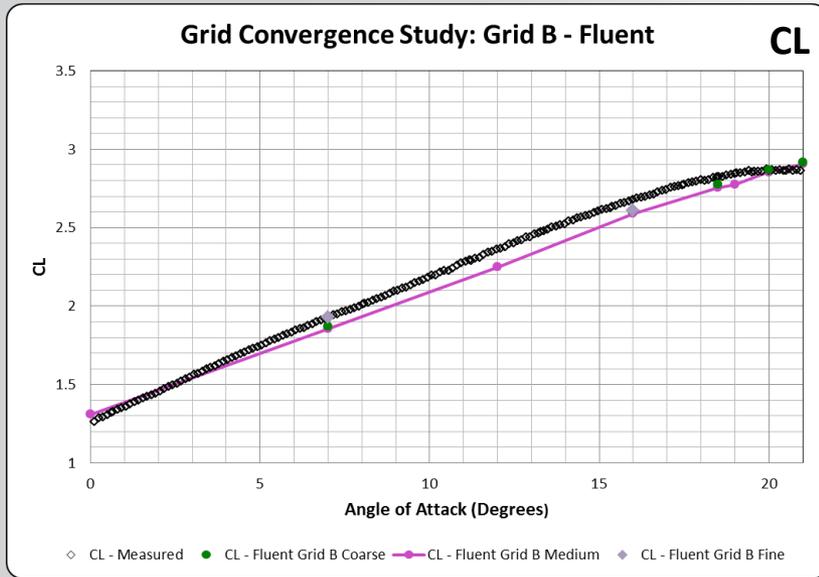
- Meshes considered
  - Grid B Coarse
  - Grid B Medium
  - Grid B Fine
  - And all the above converted to polyhedra (Fluent)



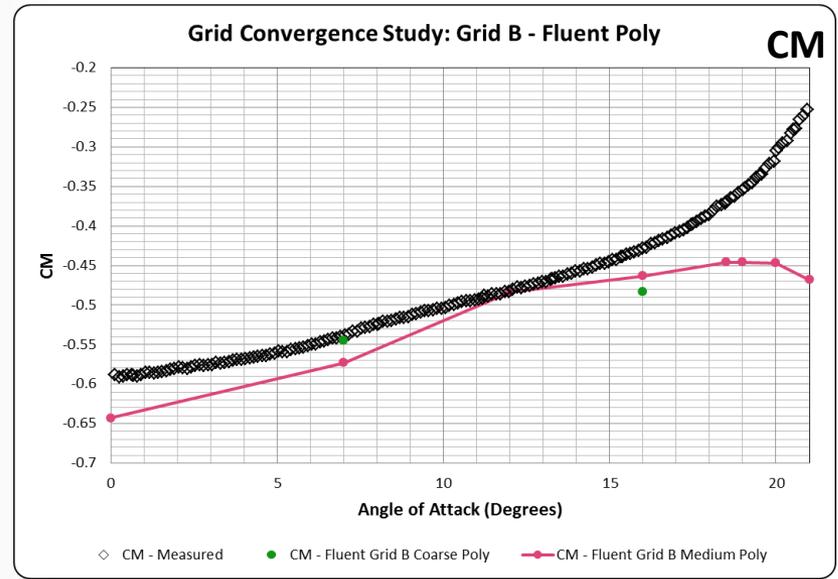
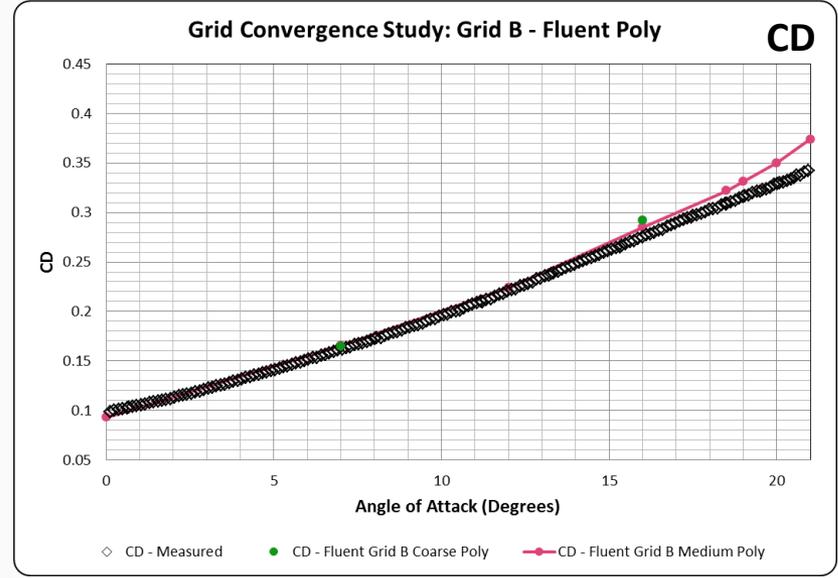
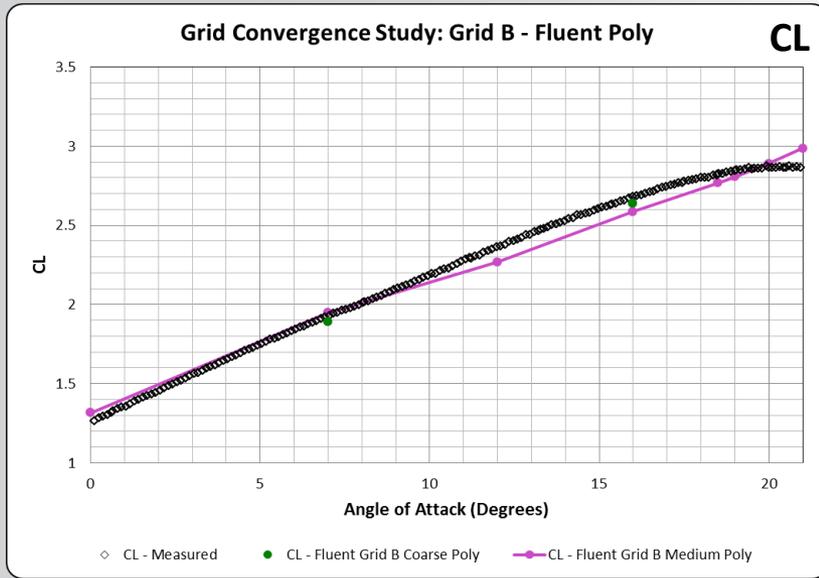
# Grid Convergence Study: Results



# Grid Convergence Study: Results



# Grid Convergence Study: Results



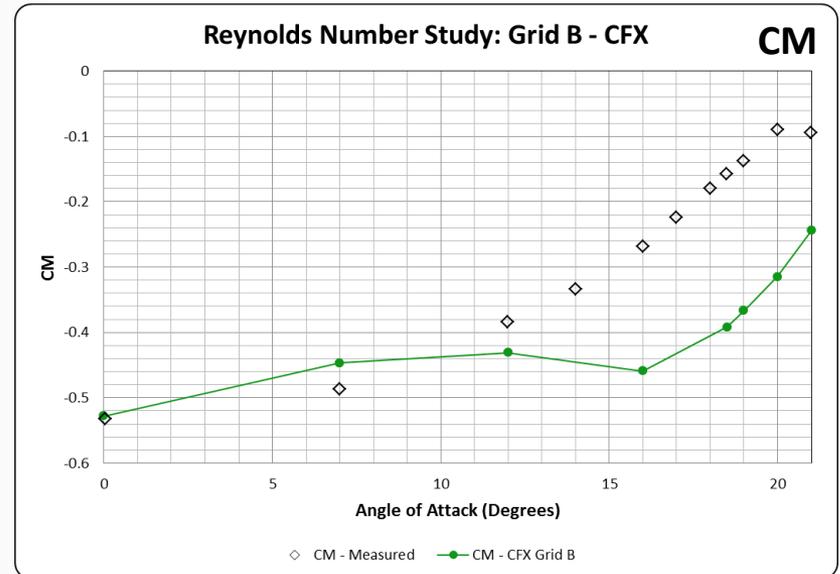
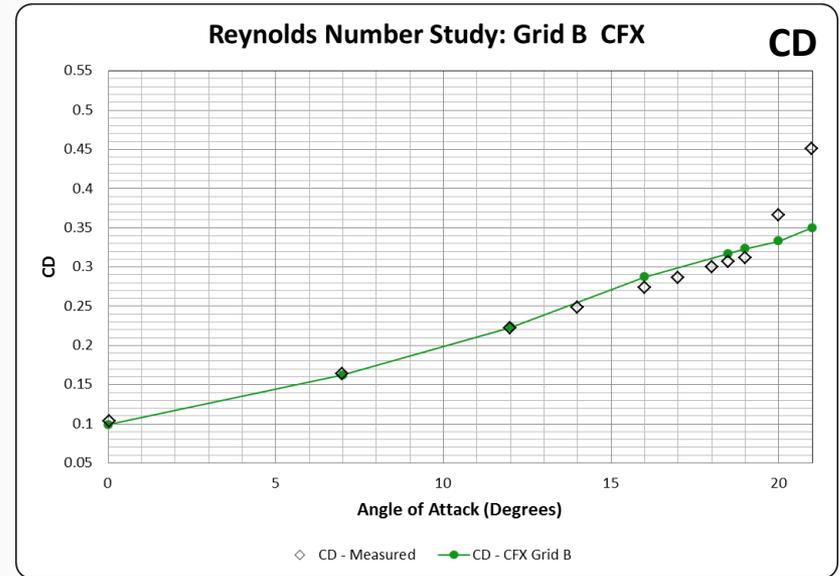
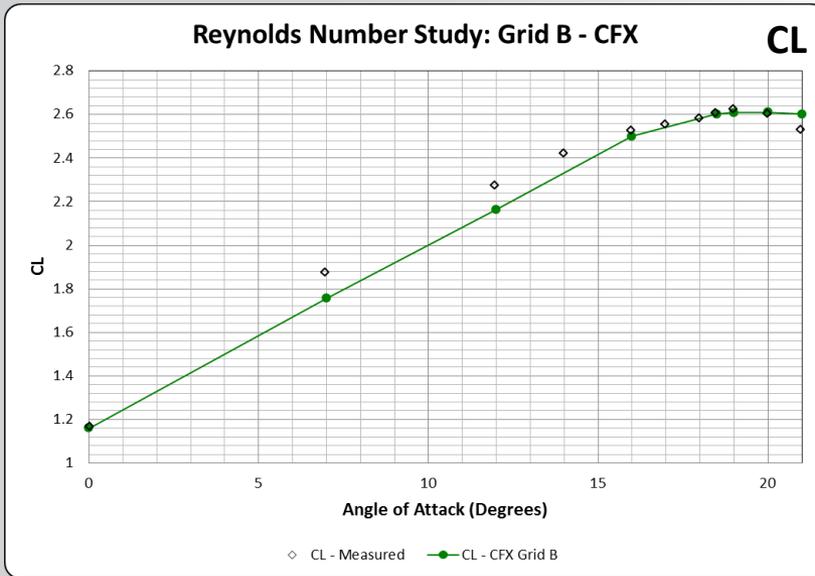
# Grid Convergence Study: Observations

- **Satisfactory grid convergence achieved on Medium mesh**
  - CFX was not run on fine mesh due to import issues
- **Overall correct trends are predicted**
  - Moment coefficient proved most difficult
  - All predictions were off the track at higher AoAs
- **Polyhedral mesh conversion resulted in 2 to 3 times faster solution, with similar or improved accuracy**
  - Only poly meshes are used for the Reynolds number study with Fluent

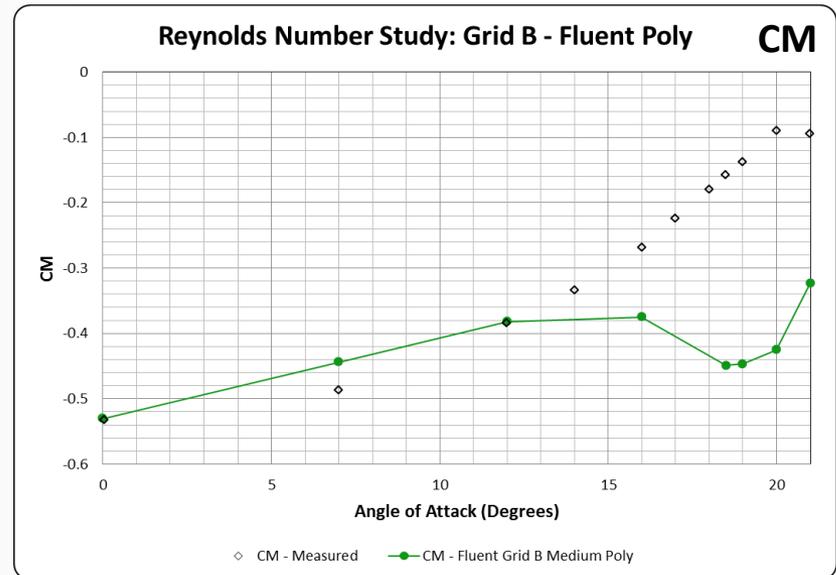
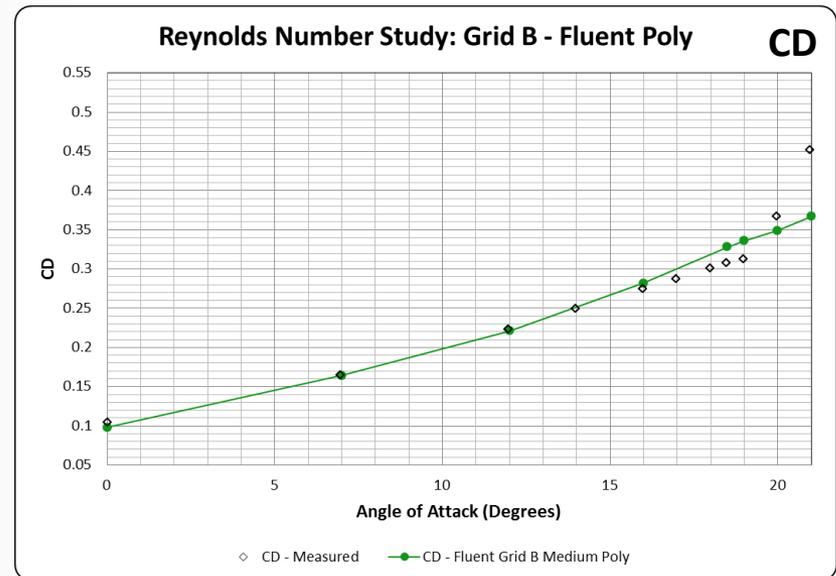
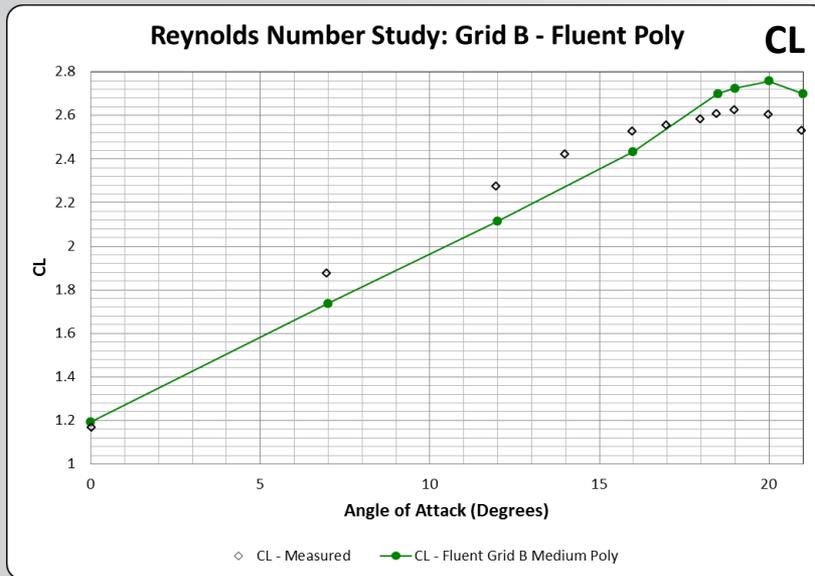
# Reynolds Number Study: Meshes

- **Meshes considered**
  - Grid B Medium
  - Grid B Medium converted to polyhedra (Fluent)
- **Note about the Geometry**
  - Simulations were performed with the geometry without including the fairings
  - Experimental results (for low Re case) are available for the geometry that includes fairings
  - This difference in the configuration can lead to some discrepancy in the results

# Reynolds Number Study: Forces/Moments

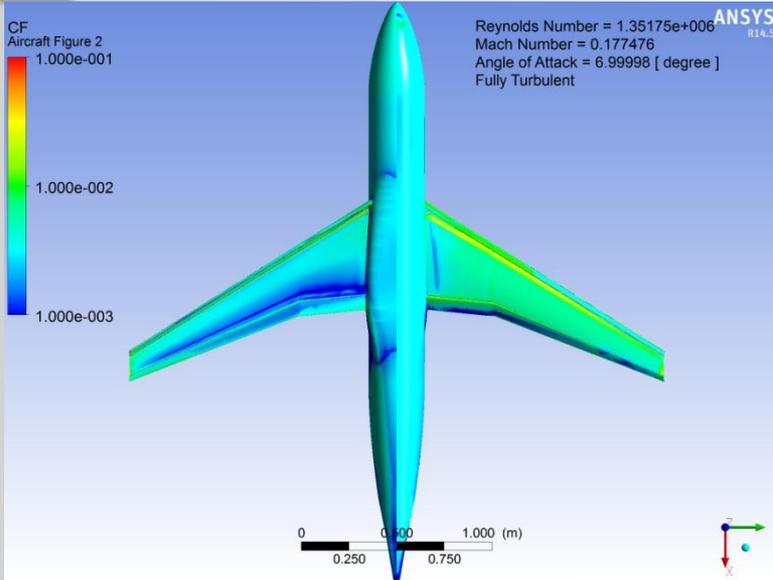


# Reynolds Number Study: Forces/Moments

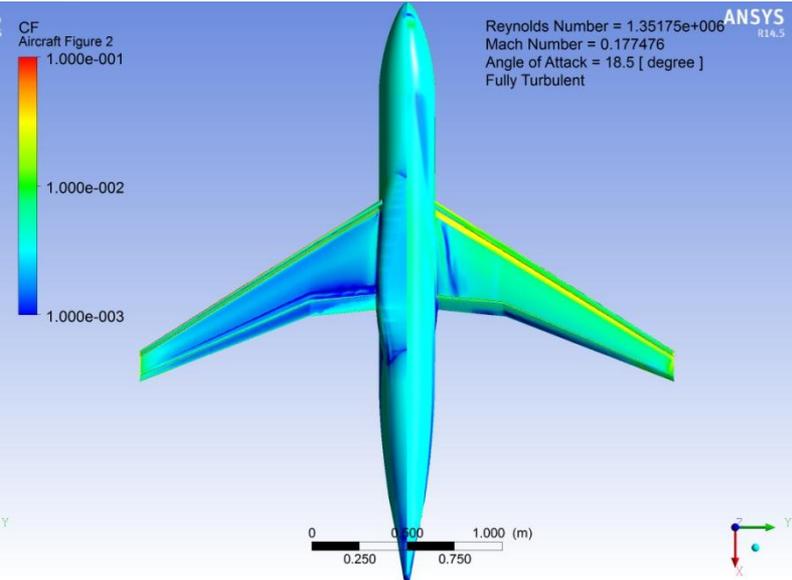


# CF: Grid B Fluent Poly

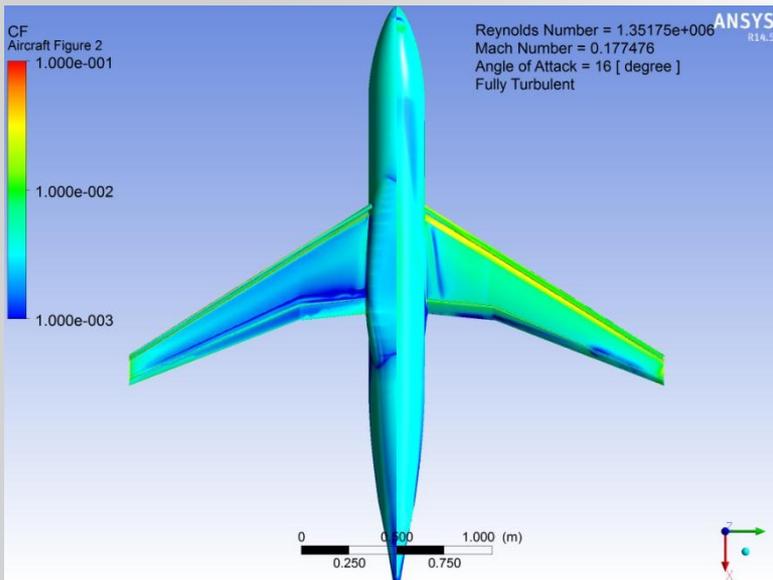
7°



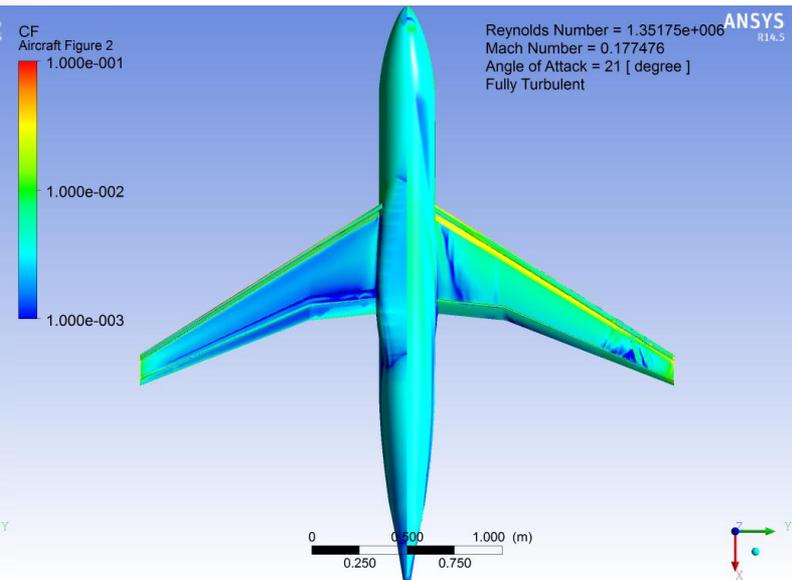
18.5°



16°

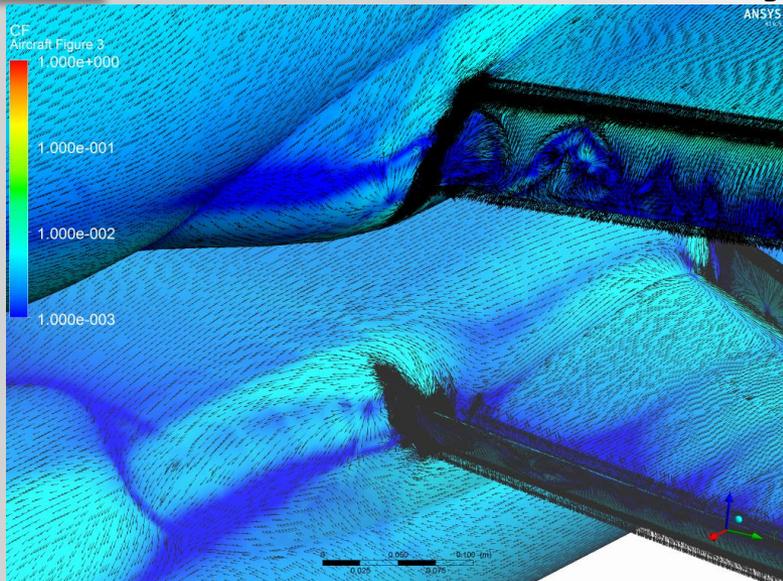


21°

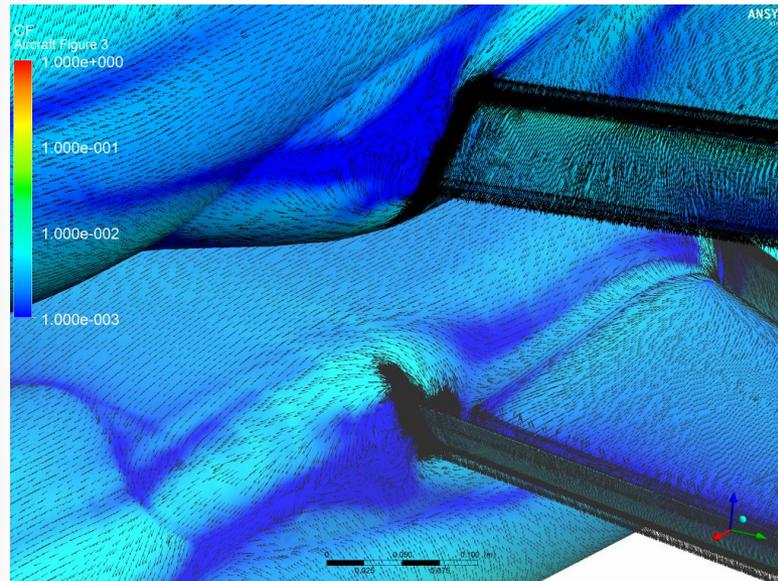


# Grid B Fluent Poly Low Re

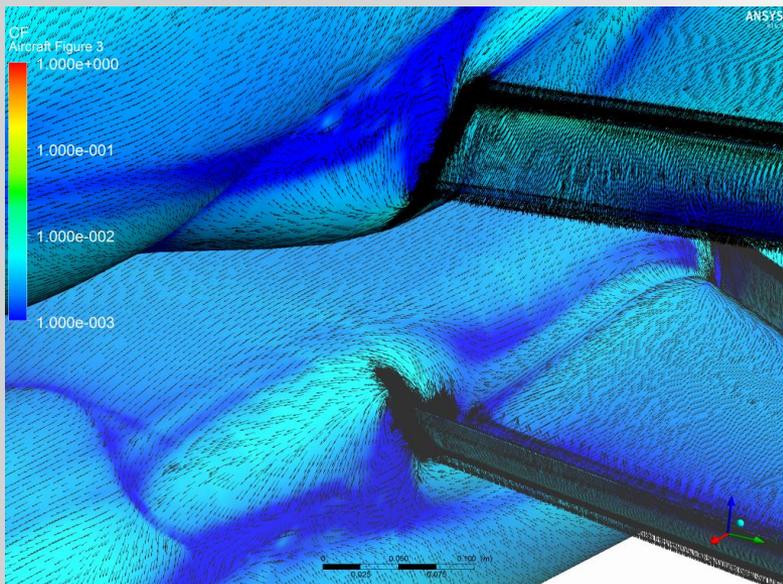
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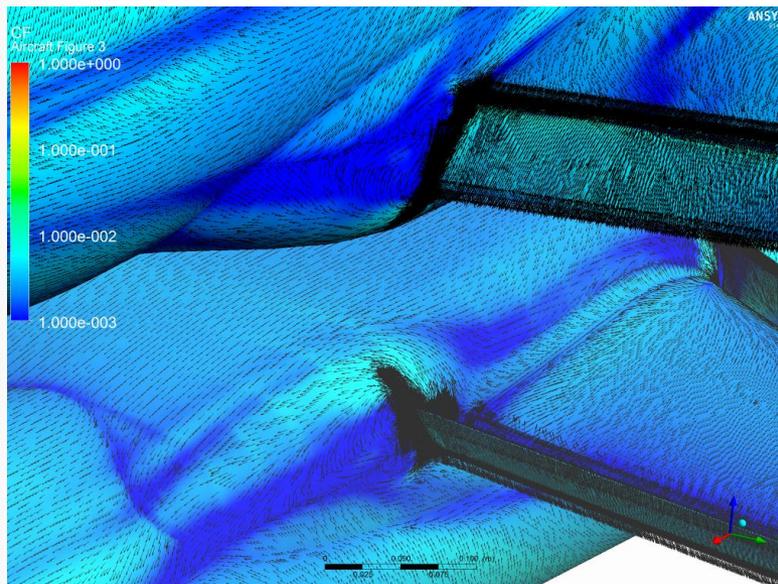
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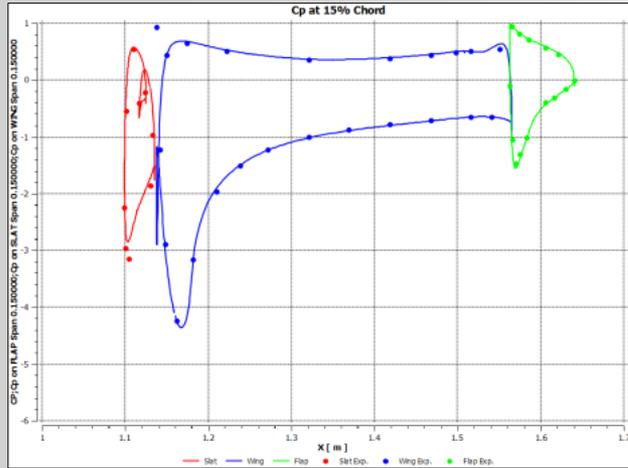


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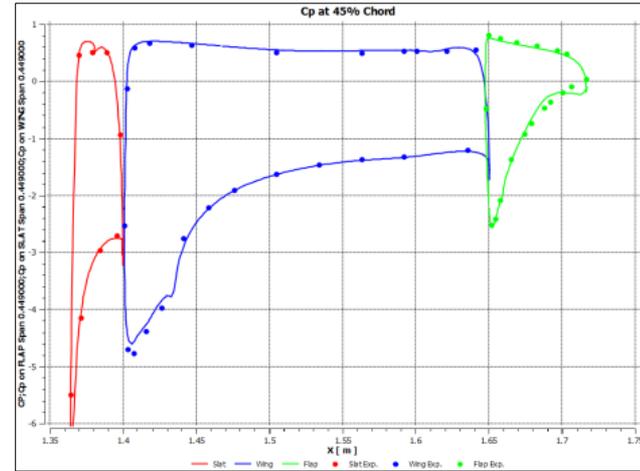


# Fluent: CP Distribution at 16°

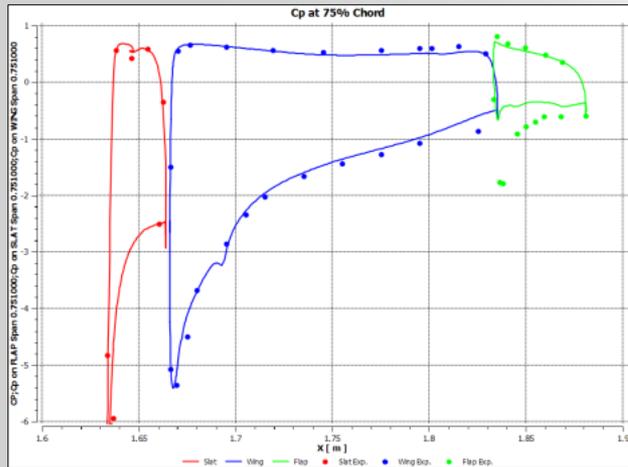
## 15% Span



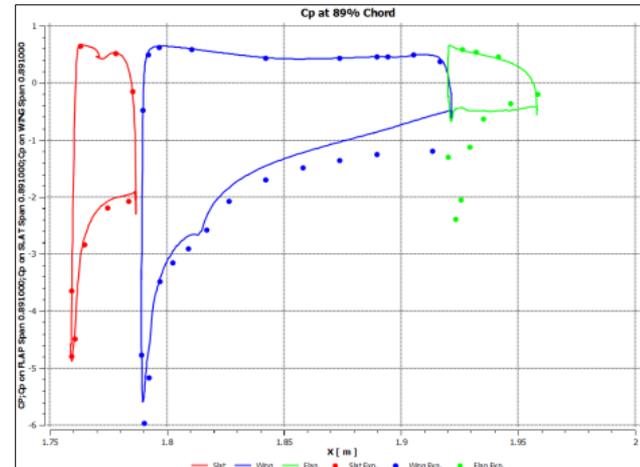
## 45% Span



## 75% Span

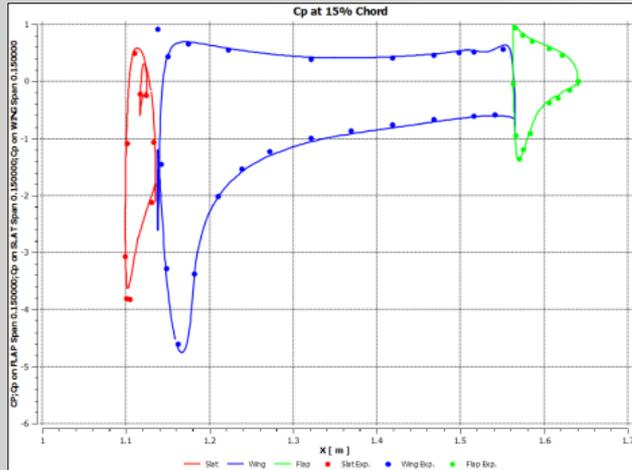


## 89% Span

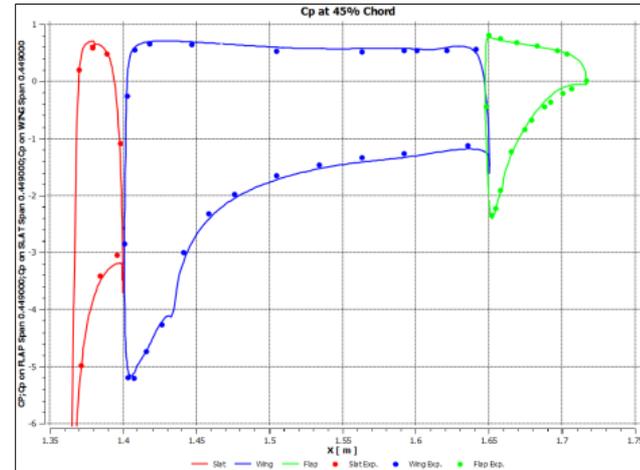


# Fluent: CP Distribution at 18.5°

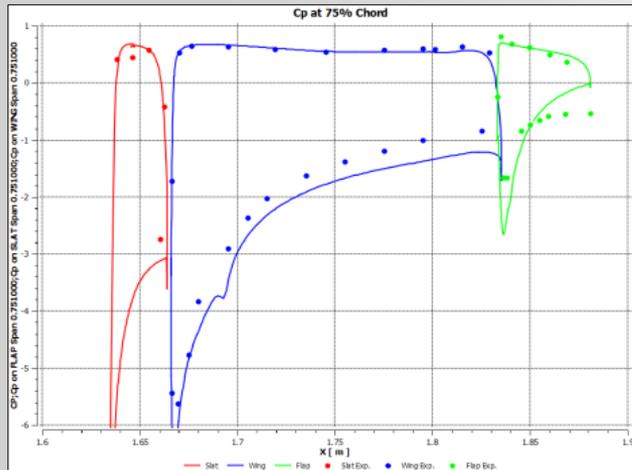
## 15% Span



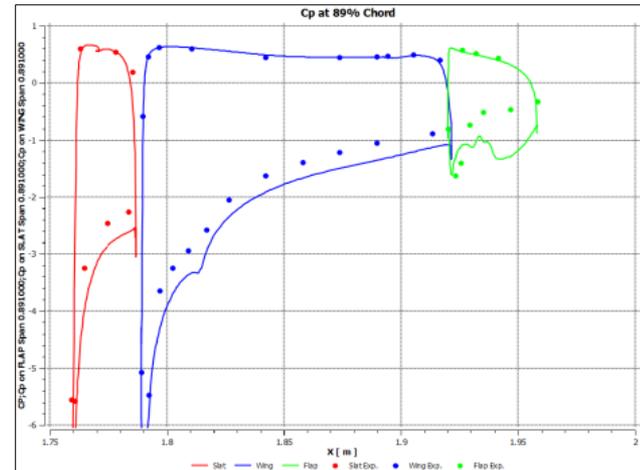
## 45% Span



## 75% Span

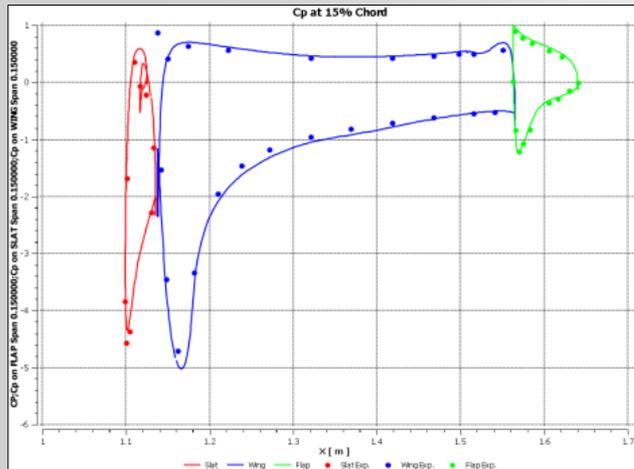


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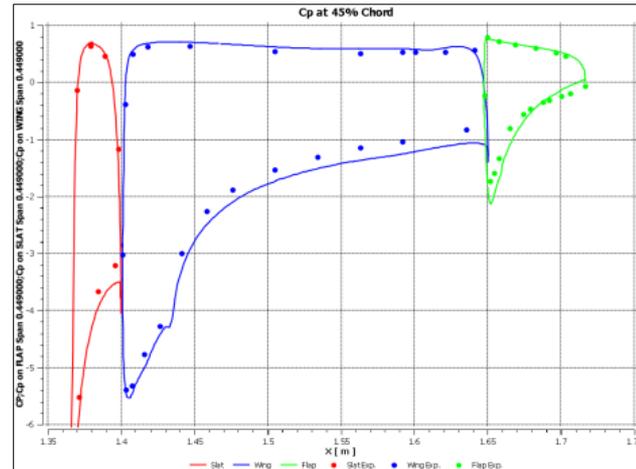


# Fluent: CP Distribution at 21°

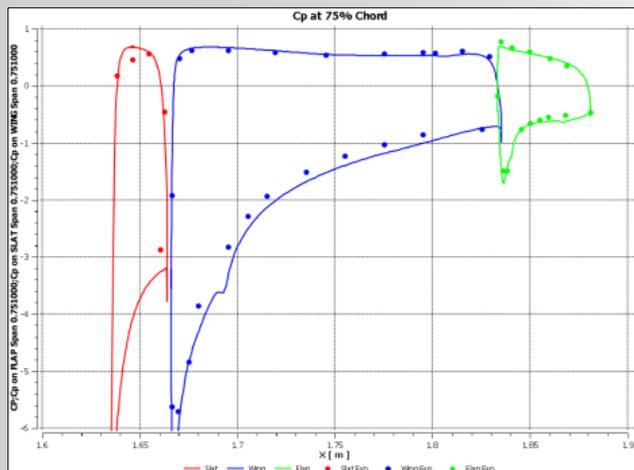
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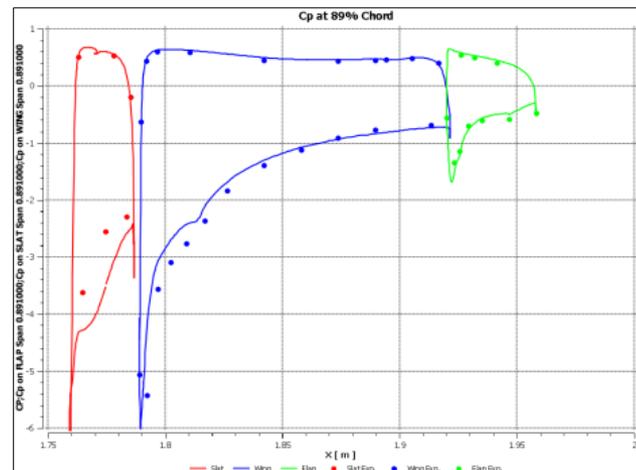
## 45% Span



## 75% Span

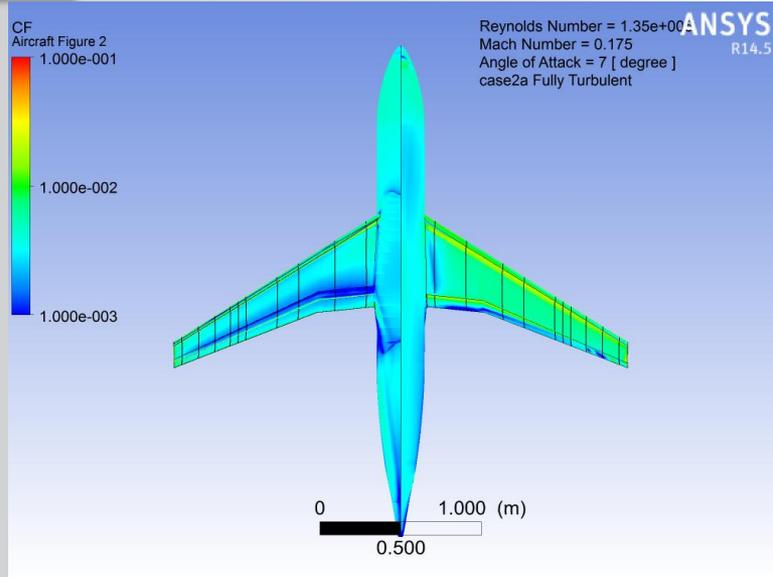


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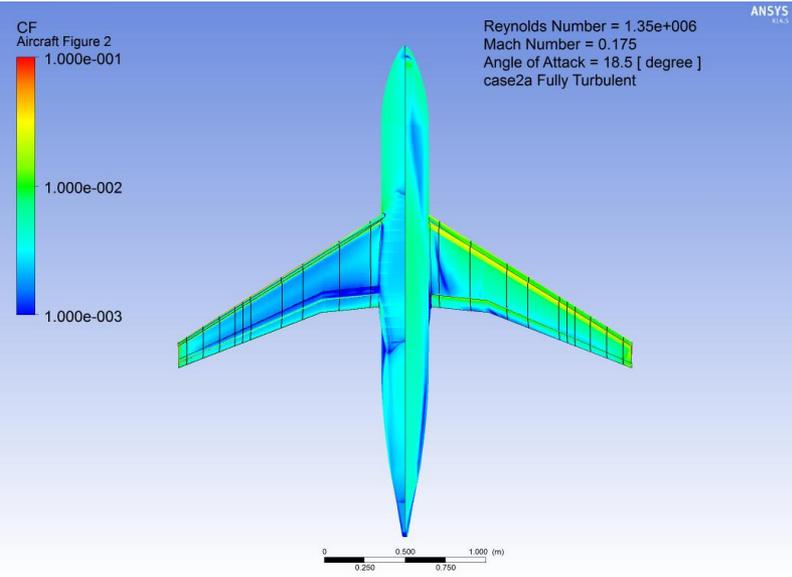


# CF: Grid B CFX

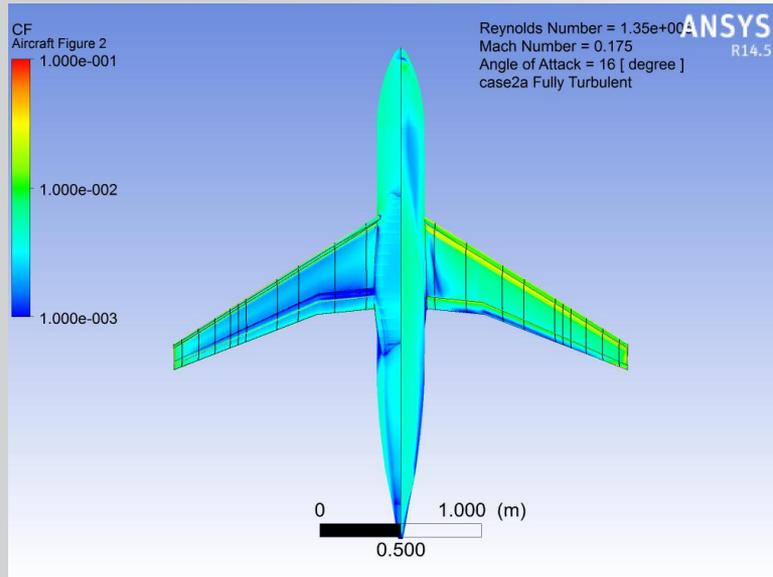
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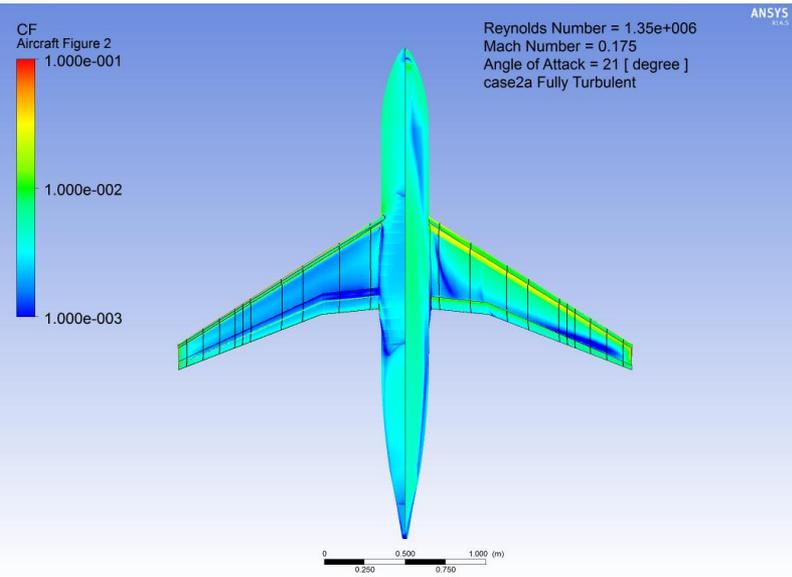
18.5°



16°

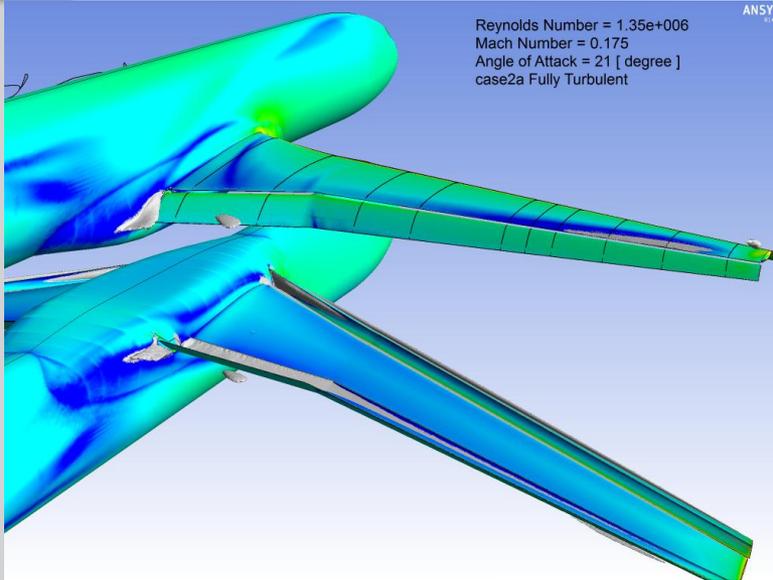


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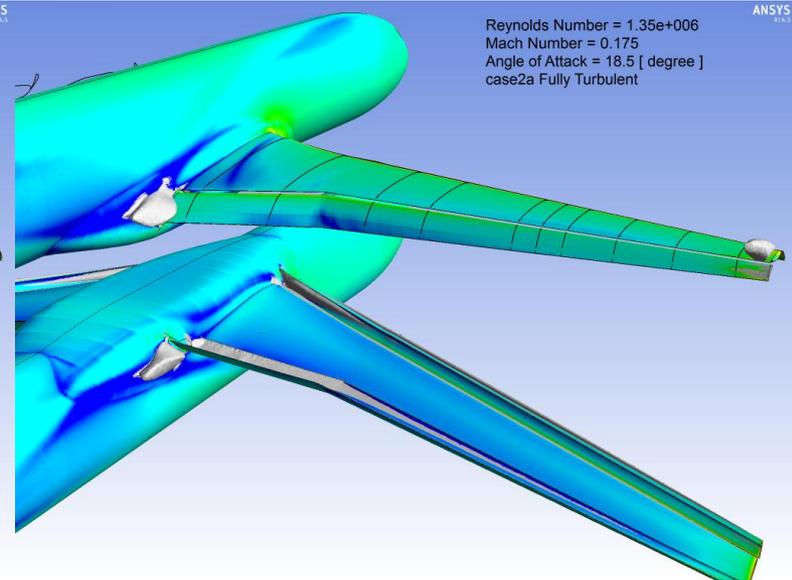


# CF: Grid B CFX

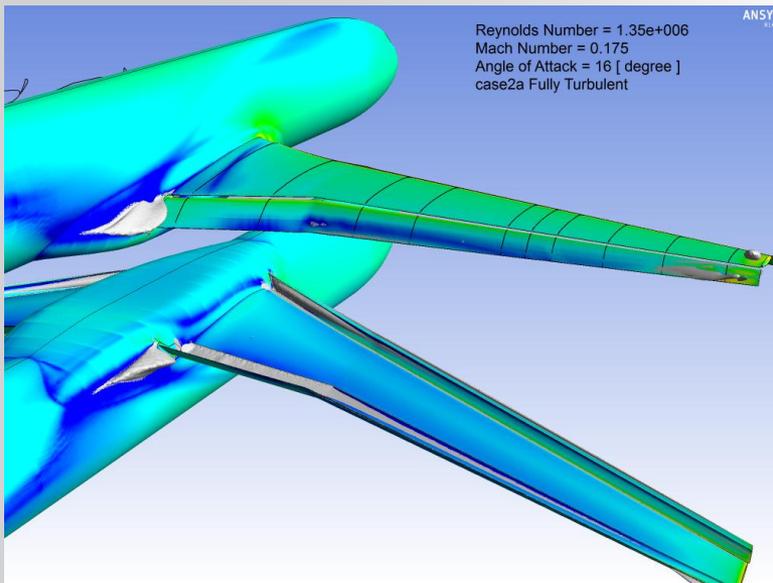
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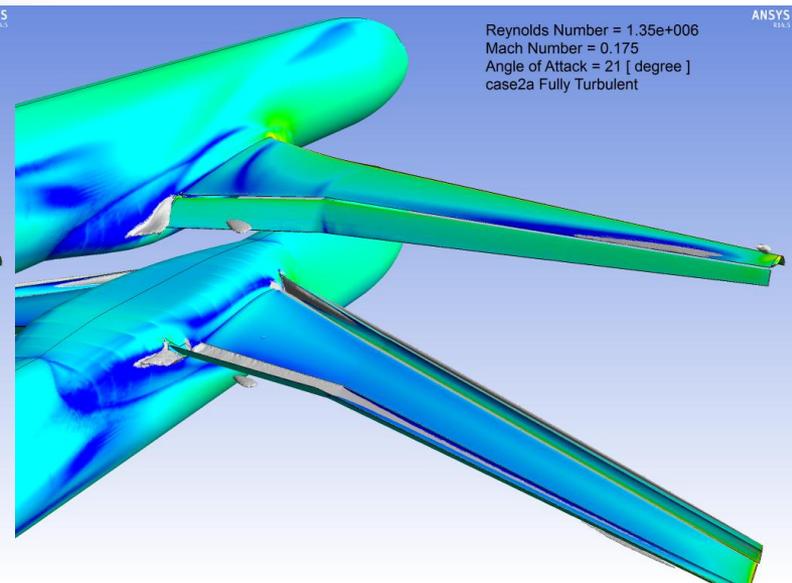
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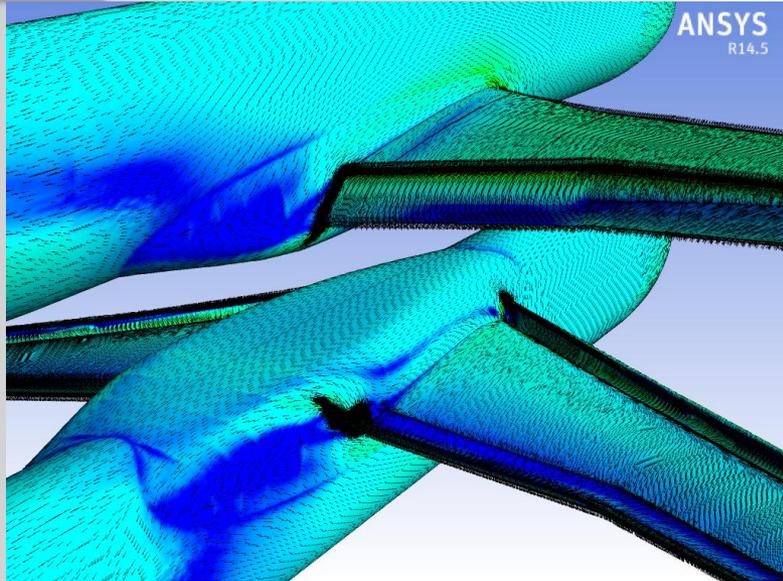


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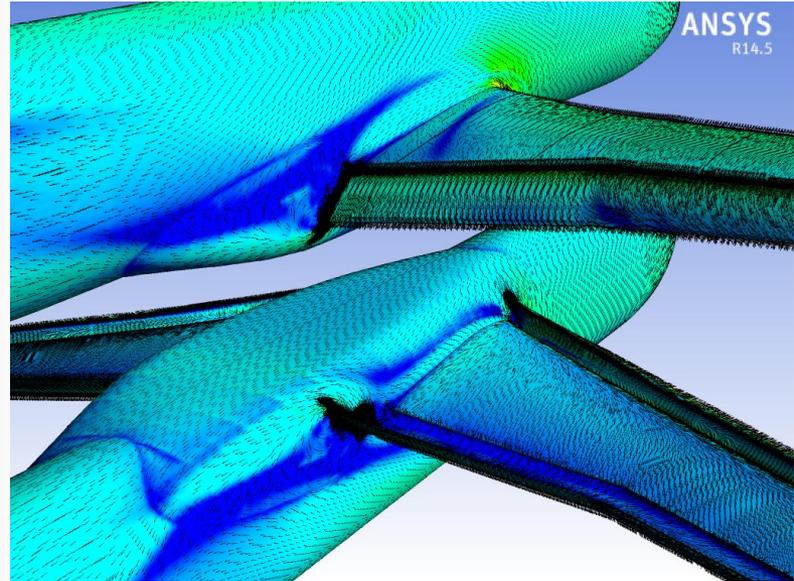


# Grid B CFX Low Re

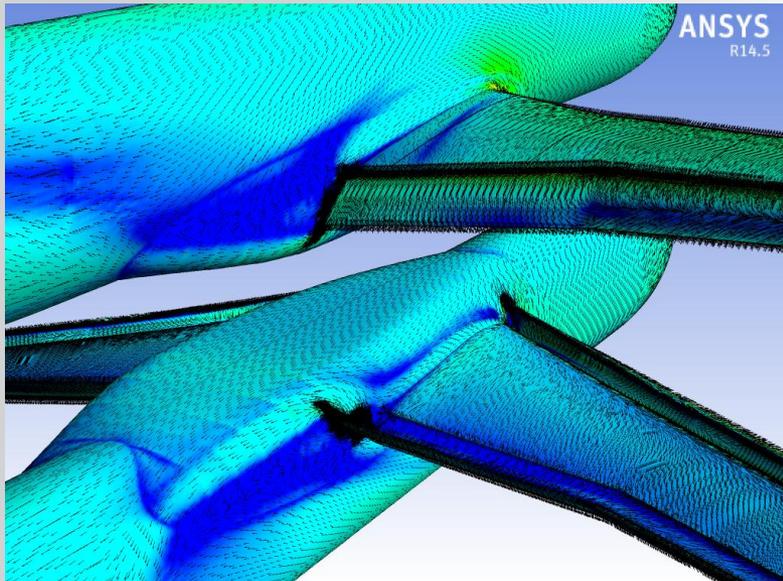
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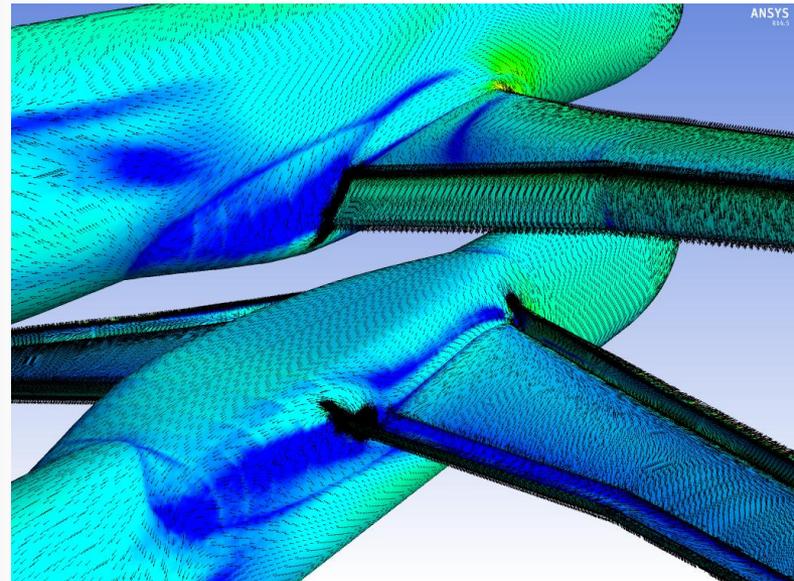
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16°

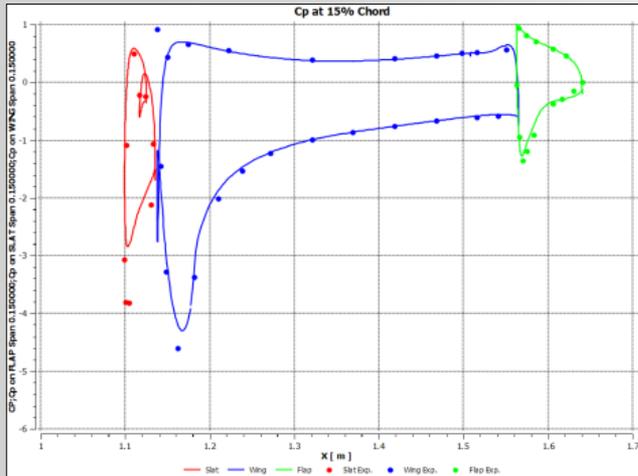


21°

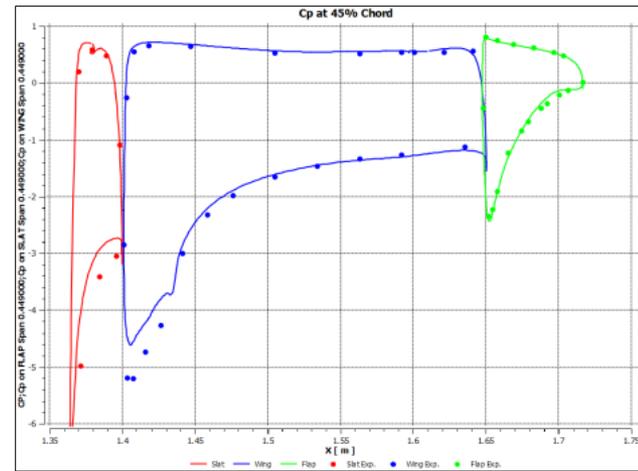


# CFX: CP Distribution at 16°

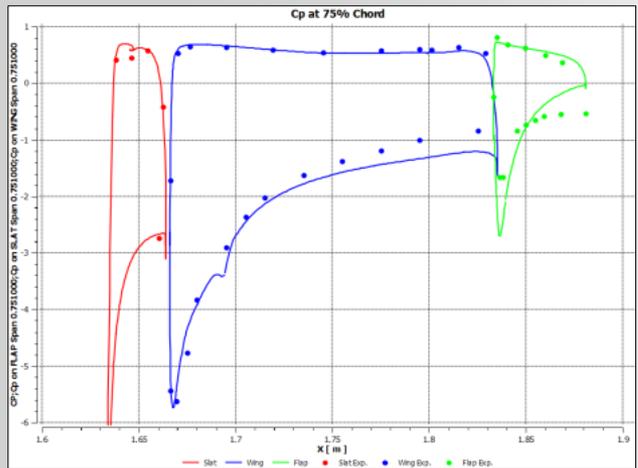
15% Span



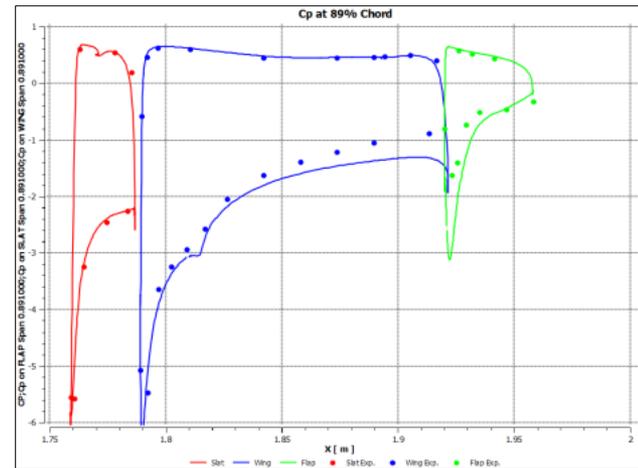
45% Span



75% Span

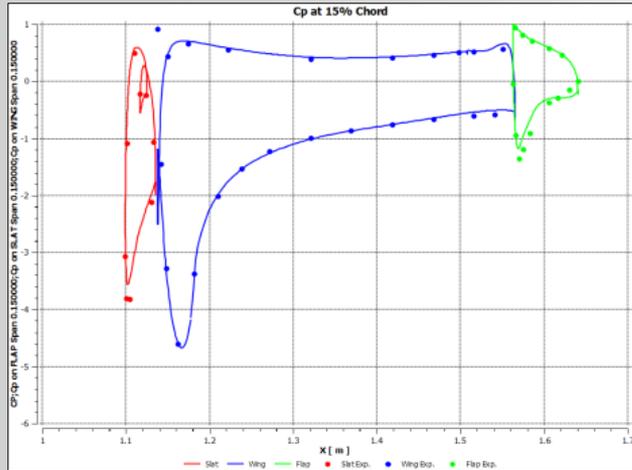


89% Span

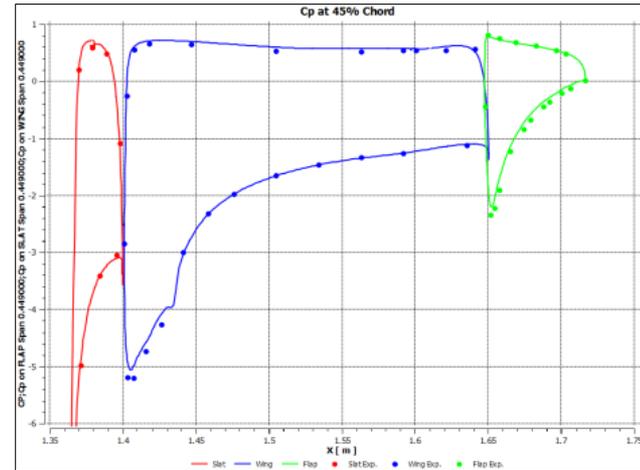


# CFX: CP Distribution at 18.5°

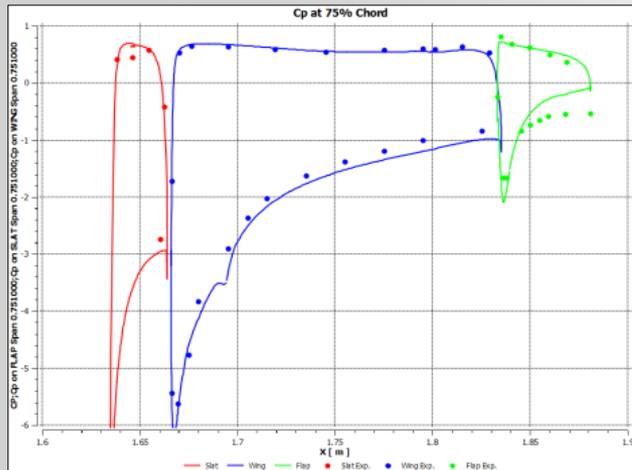
## 15% Span



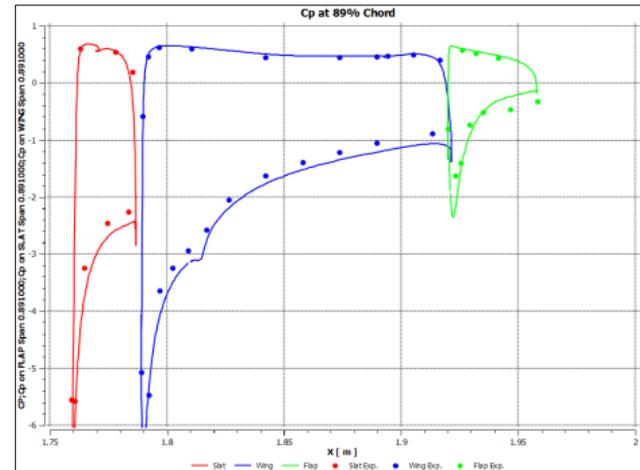
## 45% Span



## 75% Span

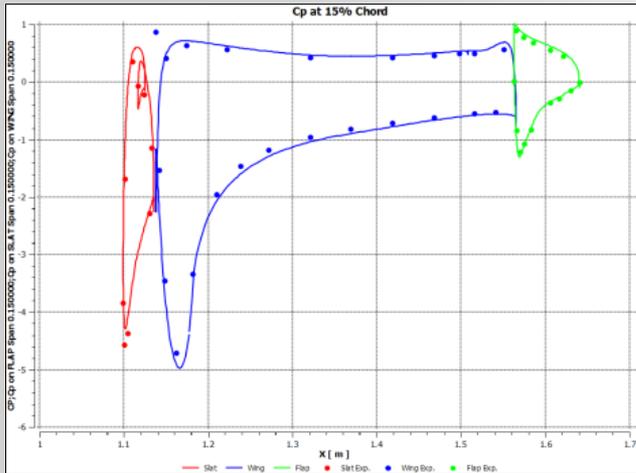


## 89% Span

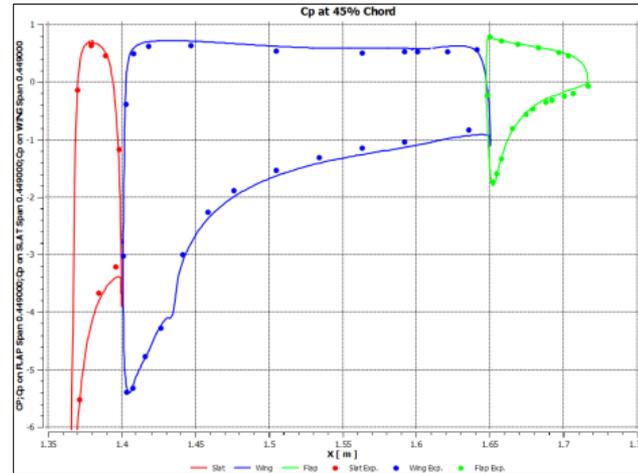


# CFX: CP Distribution at 21°

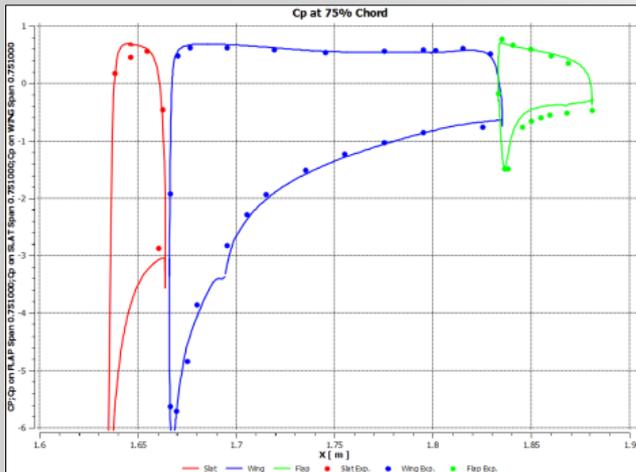
### 15% Span



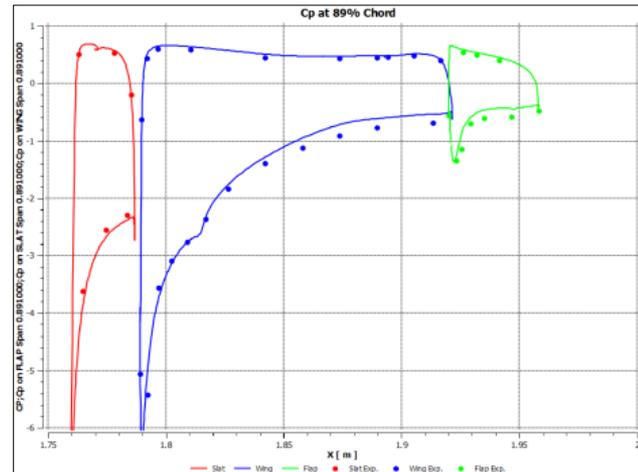
### 45% Span



### 75% Span



### 89% Span



# Reynolds number study: observations

- SST k-w model has performed well even for the low Re case
- CP matched well at inboard stations
- CP deviated more at outboard stations
- CL, CD showed correct trends and stall prediction
- CM predictions were off from the experimental data
- Lack of fairings in the simulation geometry must have contributed to some of the discrepancies

# A note on Transition model results

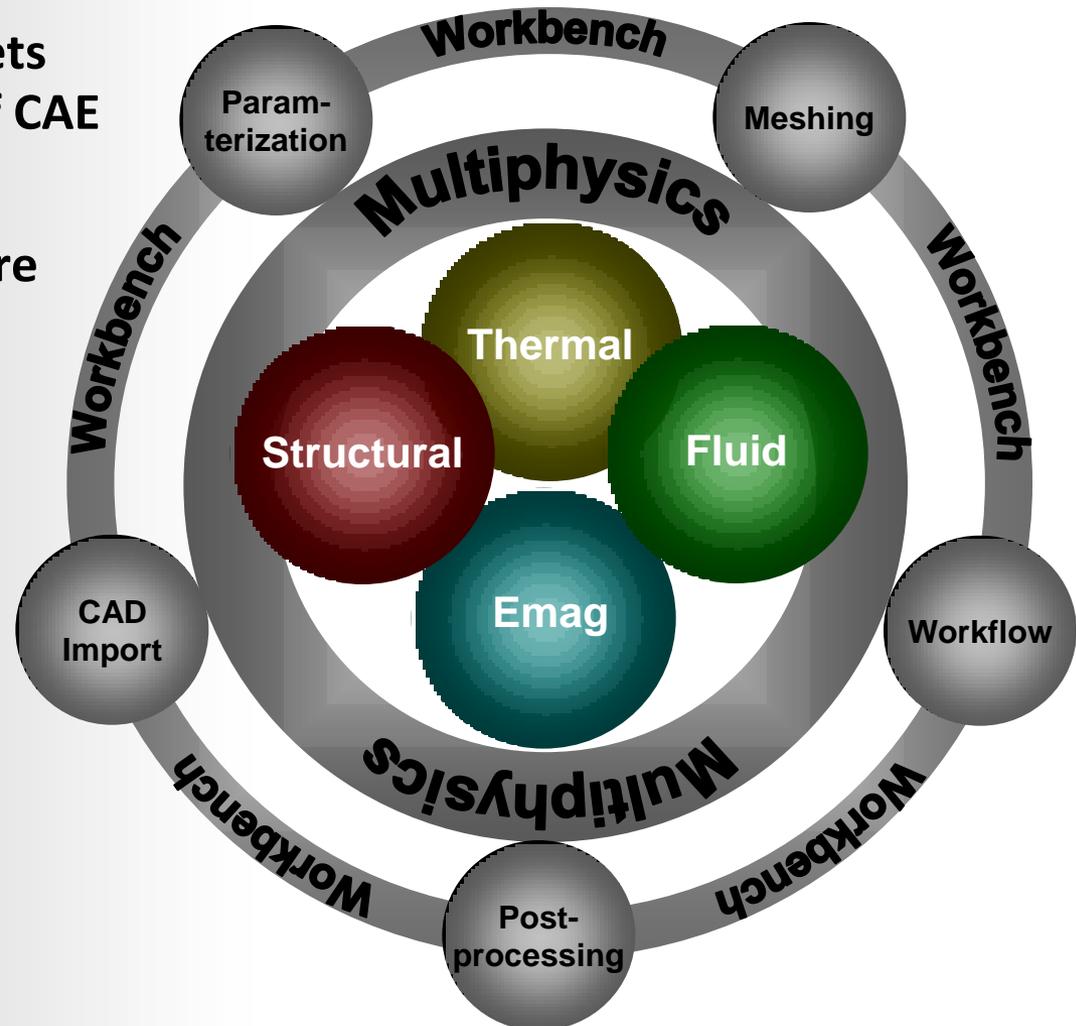
- **The transition results were removed from this presentation as they require further investigation of inlet conditions and mesh resolution**
- **The transition cases will be recomputed and the results will be made available later**

# Summary

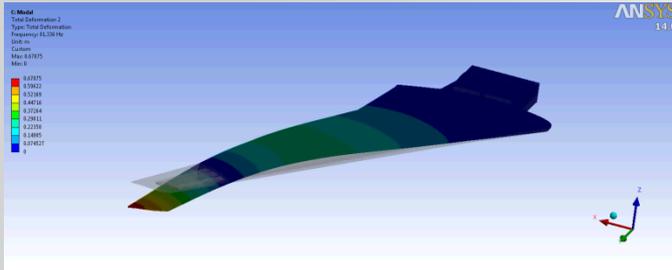
- **Excellent prediction of trends and accurate force/moment predictions with hybrid meshes in CFX and hybrid/poly meshes in Fluent**
- **Poly meshes improved the accuracy for Fluent**
- **Poly meshes have shown speed up of 2 to 3 times compared to hybrid meshes**
- **SST k-w model has shown reasonably good results for the low Re case**
  - Missing fairings in the simulation geometry might have caused some discrepancy
  - Further tests will be done with fairings included and by using SST transition model

# About ANSYS

- ANSYS designs, develops, markets and globally supports a range of CAE simulation software
- A suite of multi-purpose software technologies for
  - Fluid Dynamics
  - Structural Mechanics
    - Implicit
    - Explicit Dynamics
  - Electromagnetics
  - Multiphysics
- Selection of specialised tools
  - Specialist thermal/flow for electronics



# ANSYS continues to actively participate in leading industry consortia & workshops



Only commercial simulation company on the organizing committee of the NASA led aeroelastic prediction workshop

Only commercial simulation company part of the Boeing led CARE consortium focused on the in cabin environment – 1D to 3D tool coupling focus

## 2nd AIAA CFD High Lift Prediction Workshop (HiLiftPW-2)

Sponsored by the Applied Aerodynamics Technical Committee

2-Day Workshop - June 22-23, 2013  
 Sheraton San Diego Hotel & Marina, San Diego, CA  
 (Associated with the 31st AIAA Applied Aerodynamics Conference)



Continued participation in AIAA High Lift, Drag Prediction and Propulsion Aerodynamics Workshops