HIRENASD
Static and Dynamic Analysis with Edge

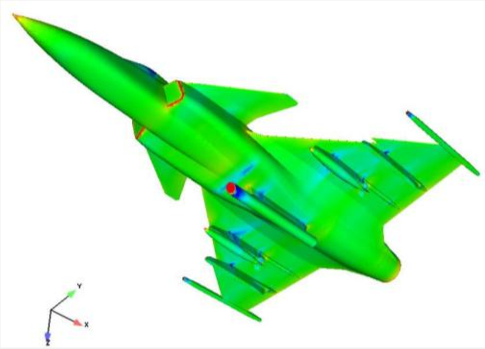
Adam Jirasek and Mats Dalenbring

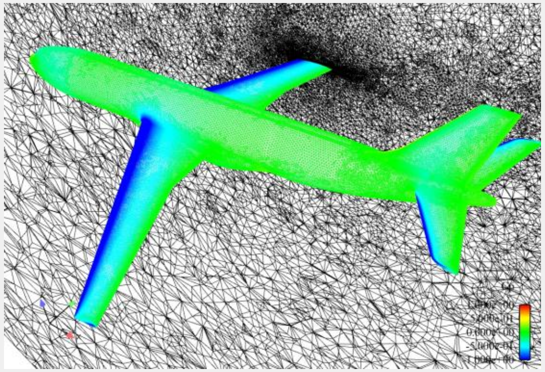
Swedish Defence Research Agency, FOI

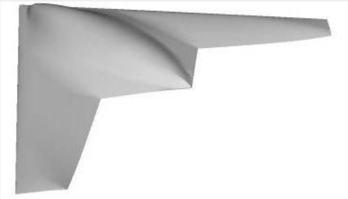
Stockholm, SE

Edge – a CFD code for unstructured grids

- Independent in-house code, developed since 1997 at FOI (and former FFA)
- State-of-art flow solver for the compressible Euler and Navier-Stokes equations
- Steady-state and time dependent solutions on unstructured grids
- Fully parallel, scalable, no size limit. High efficiency
- FOI code, available as a complete source package, subject to the FOI license agreement. Today developed in collaboration with selected external partners. Used also in teaching and for research at different universities
- Saab Aerosystems main CFD tool







Edge - main CFD system

CAD repair → Grid Generation → Pre-processor dual mesh etc → Edge CFD Flow Solver → Post-processing tools / converters

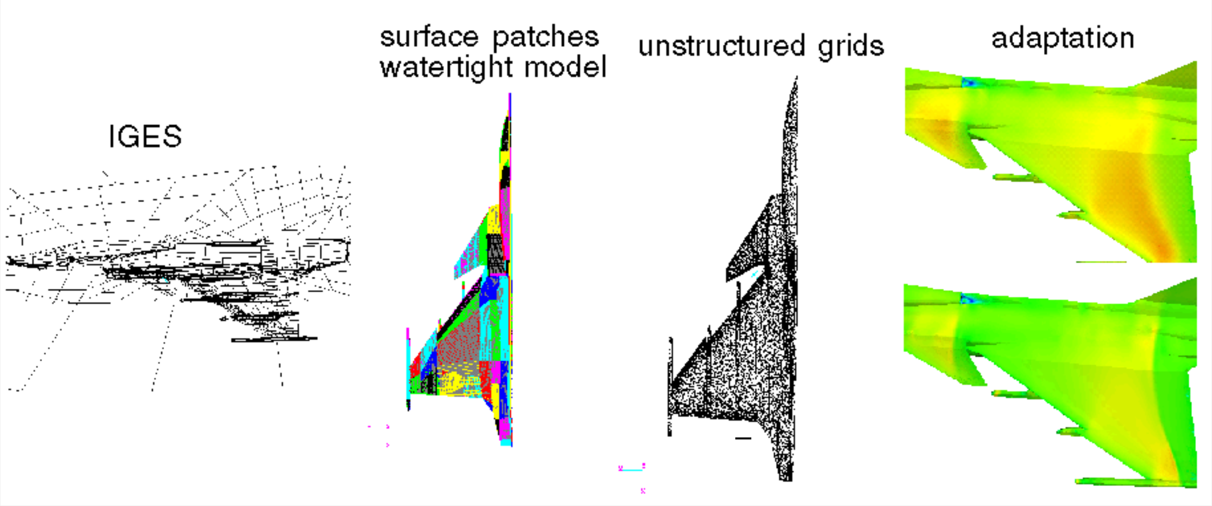
Edge CFD Flow Solver → h-Adaption → Pre-processor dual mesh etc

Post-processing tools / converters → Visualisation & Analysis

FOI : TRITET

Pro Engineer™

ICEM™ & others



EnSight™

Fieldview™

Matlab™

ParaView.org

Edge – functionalities

Main functionalities

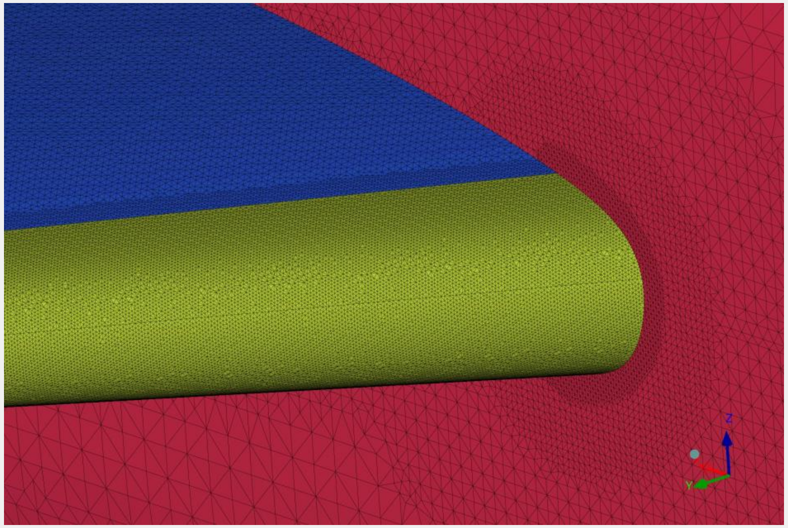
- High (hypersonic) and low speed (incompressible) extensions
- Grid adaptation
- Many turbulence models. RANS, LES, hybrid
- Many numerical algorithms available
- Highly efficient convergence acceleration techniques

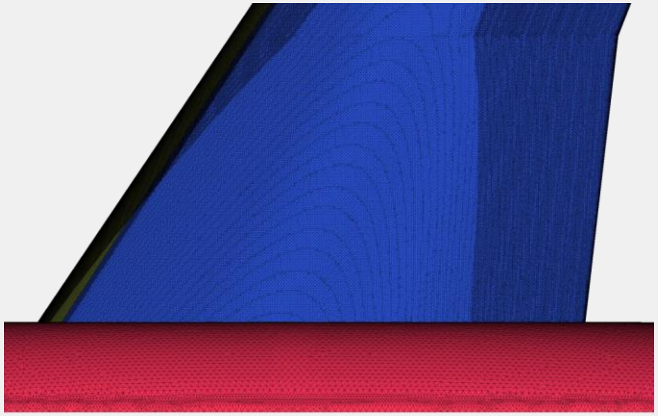
Special functionalities

- Fluid-structure interaction capabilities
- Models for flow control
- Solver of the adjoint flow equations for shape optimization
- Coupling to transition prediction tools

CFD Mesh Overview

- Three meshes generated
  - Mostly respecting gridding guidelines
  - Coarse (approx 6.5 mil nodes)
  - Medium (approx 22 mil nodes)
  - Fine (approx 56 mil nodes)
- Rigid mesh analysis
  - RANS-SA model for all three meshes
  - Course and Medium





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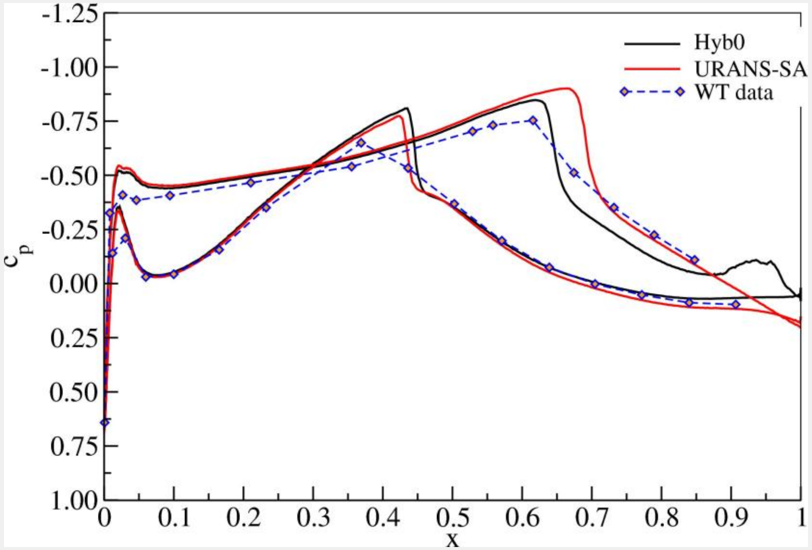
URANS-SA vs. Hybrid – Medium Mesh

- The result from the rigid wing analysis shows that the largest difference is due to different turbulence models
- $\Delta t = 2.68 \times 10^{-5}$ seconds and about 1000 time step was used
- The Hyb0 model, which belongs to the family of DES models, was able to predict the corner flow separation in the wing-fuselage junction.
- In addition, the position of the shocks is different, which causes the lift force to be about 20% lower
- And the drag force about 20% higher compared to the SA model analysis results.
- The difference between steady and unsteady SA models is almost negligible.



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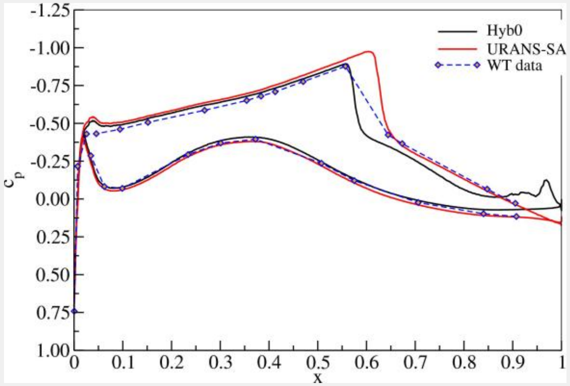
URANS-SA vs. Hybrid – Medium Mesh



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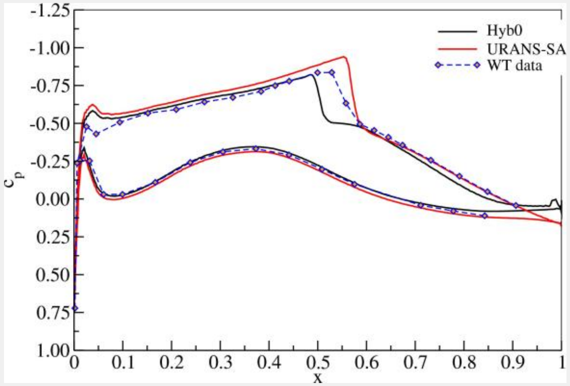

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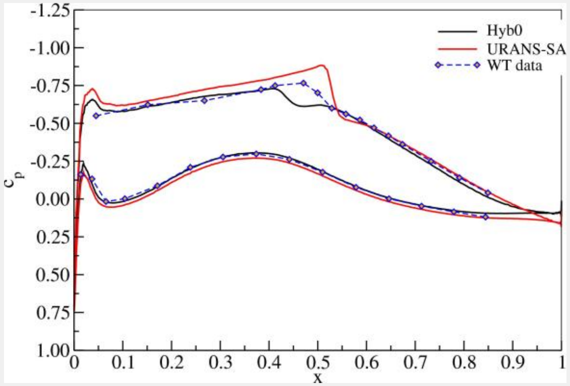

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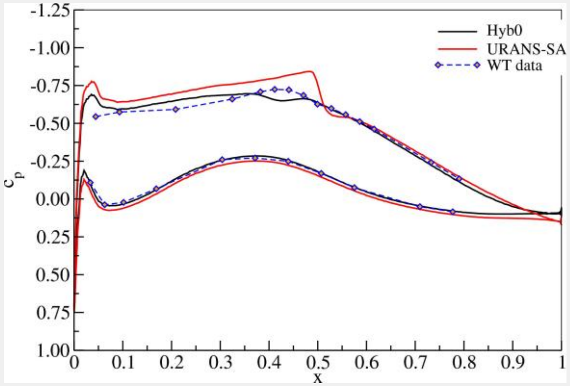

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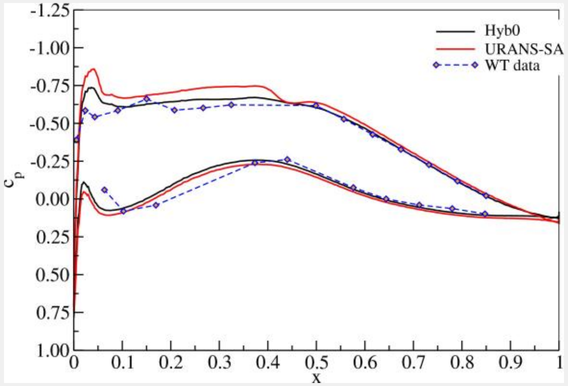

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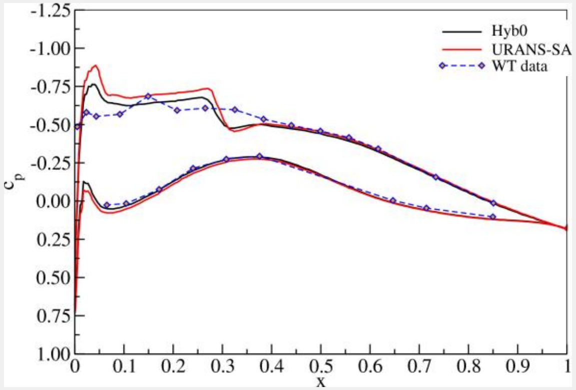

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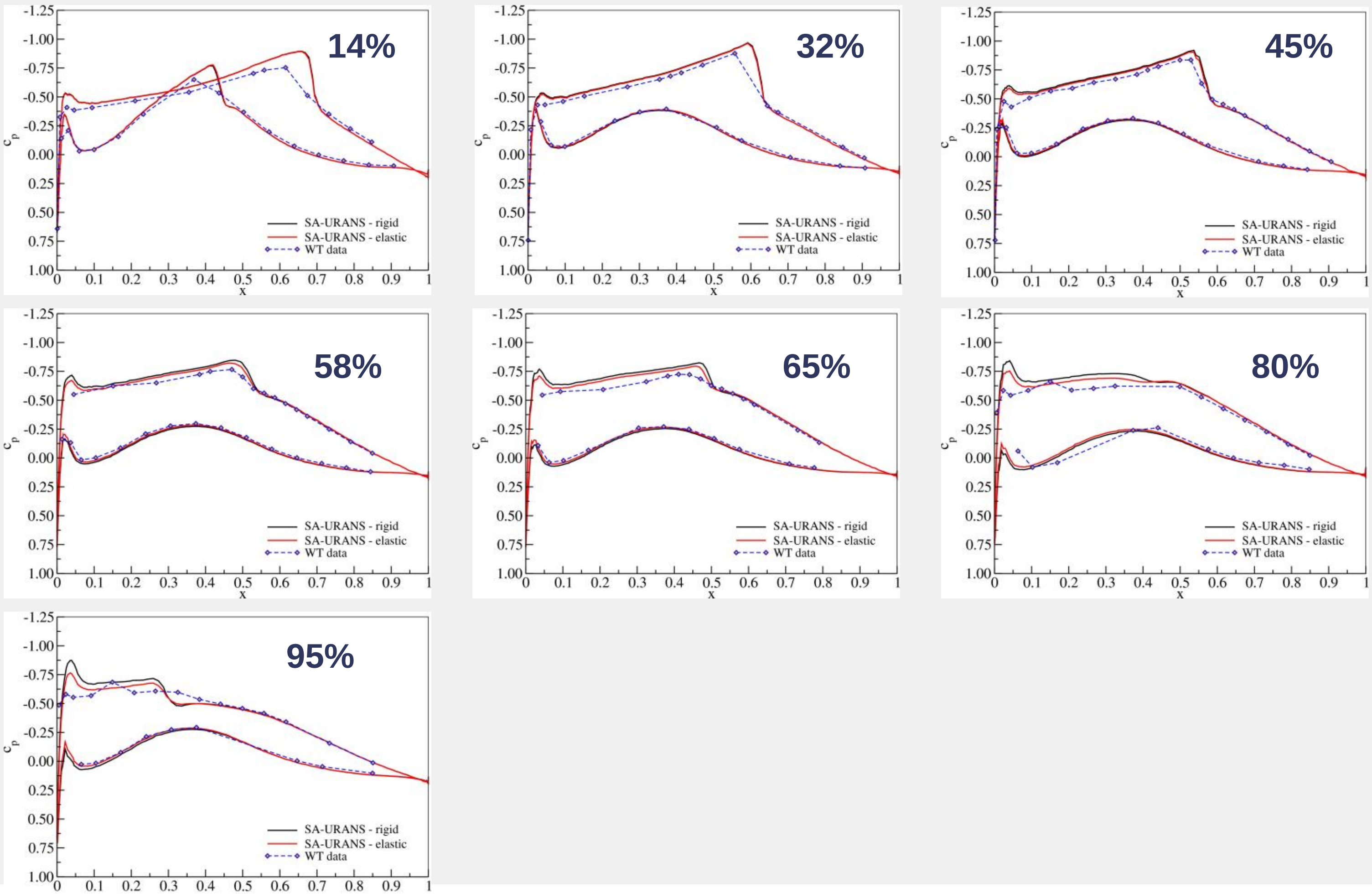
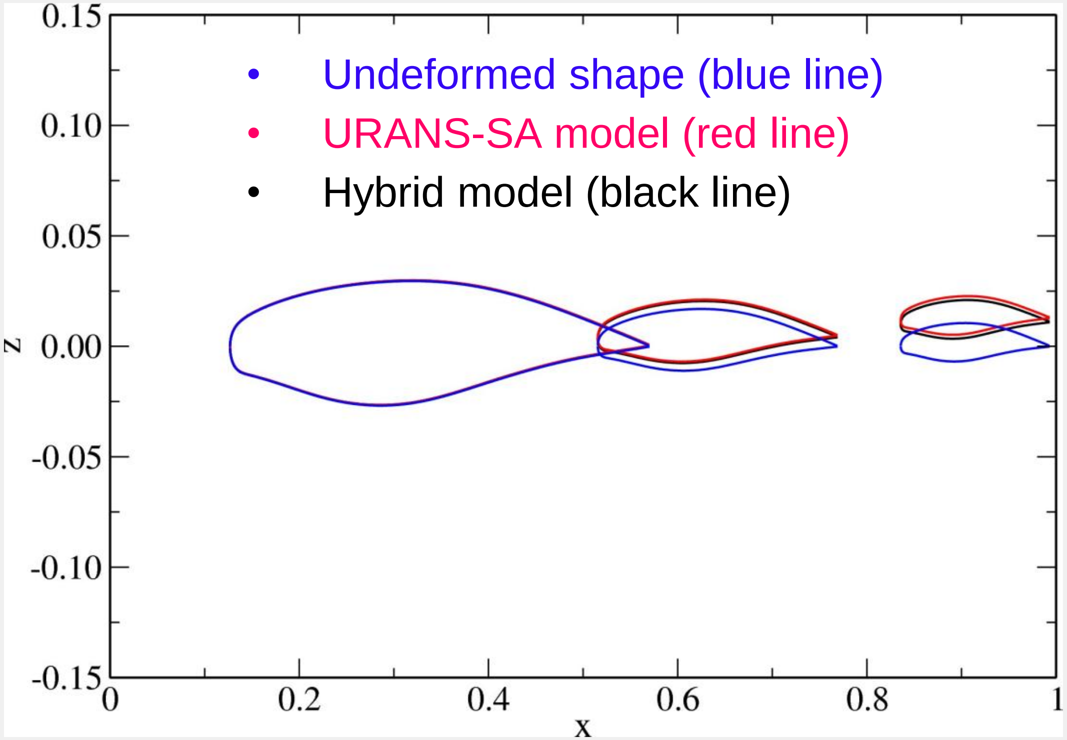
Static Aeroelastic Analysis – Coarse Mesh



Static Deformation Medium Mesh



The final deformation of the wing is about 1% displacement in the wing-normal direction and 0.4 degrees twist measured at the wing tip.

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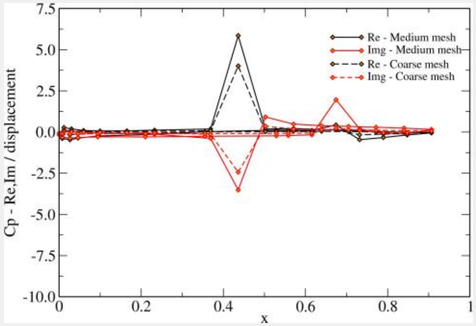
Prescribed Motion

- The dynamic aeroelasticity was calculated from prescribing cyclic surface deformation, at the second structural mode at frequency 78.9Hz.
- The coarse and medium mesh where analysed
- Only the results using the URANS-SA turbulence model is reported
- The time step set to $\Delta t = 9.90177 \times 10^{-5}$ seconds.
- A number of 128 time steps per period with the in excitation frequency period.
- Four periods were calculated to make sure the solution is converged two additional periods were simulated and the solution was sampled for each post FRF analysis.

FRF Analysis (URANS-SA)



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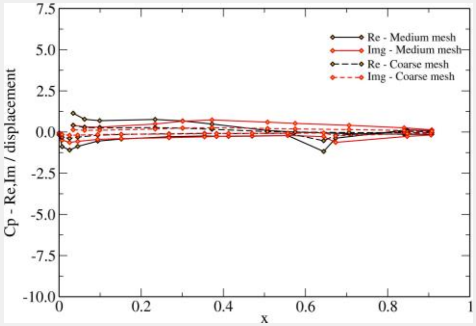

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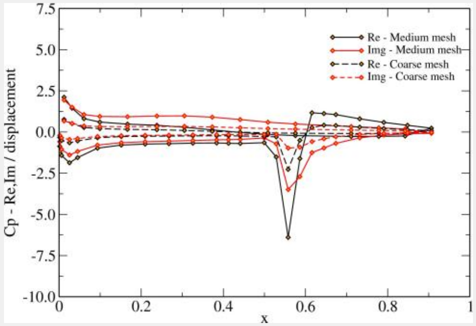

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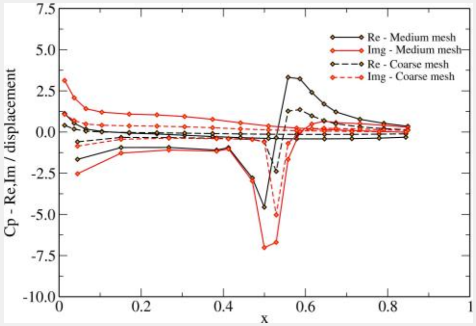

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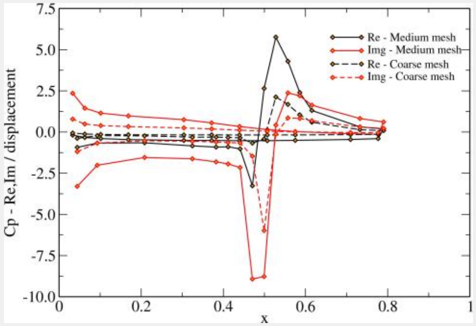

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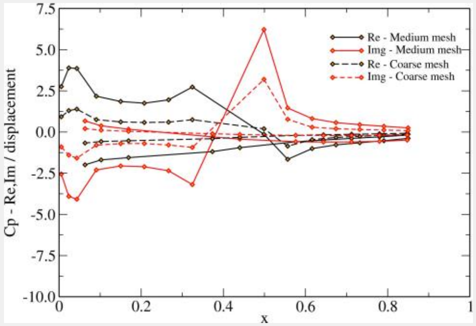

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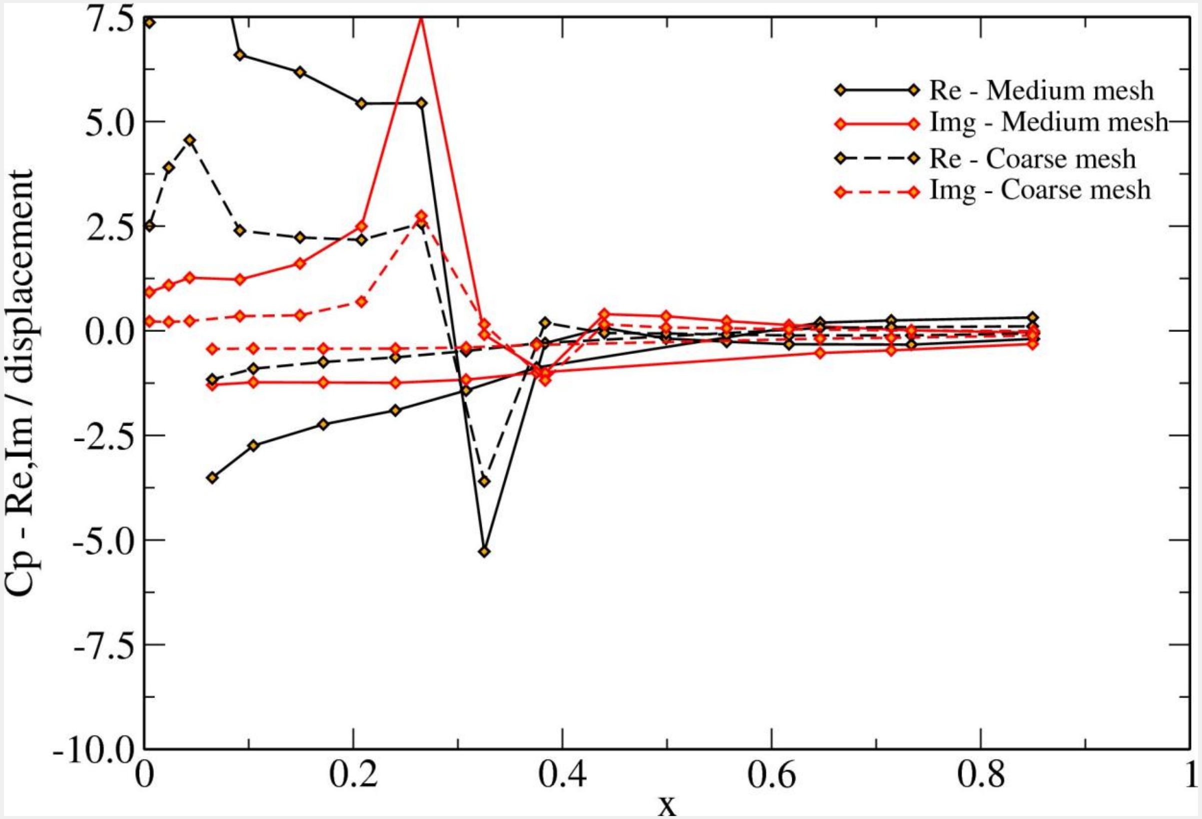
FRF Analysis URANS-SA (95%)



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Summary

- The largest difference is due to different turbulence models.
- For the Hybrid model, the position of the shocks is different compared to the SA model, causing the lift force to be about 20% lower and the drag force about 20% higher,
- The difference between steady and unsteady (SA) models is almost negligible.
- Comparison of the result using rigid and elastic model shows further reduction of the lift force in the order of 5%.

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