2nd AIAA Drag Prediction Workshop

TAU Results

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Numerical Method

• DLR-TAU software solves RANS equations
• Node-centered, hybrid grids, dual grids
• Various discretization schemes, turbulence models
• Grid adaptation
• Acceleration techniques, vectorized, parallelized
• Grids generated with Centaur from Centaursoft
• TAU was developed in the German MEGAFLOW project
Case 1: Influence of Grid Density
Case 1: Influence of Grid Density
Case 1: Influence of Grid Density
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Case 1: Influence of Grid Density

\[ \eta = 0.331 \]
\[ Ma = 0.75 \]
\[ c_L = 0.5 \]
Case 1: Influence of Grid Density

Nacelle pressure distribution

60°
Case 1: Influence of Grid Density

Nacelle pressure distribution

180°
Case 1: Influence of Grid Density

Nacelle pressure distribution

300°
Case 1: Influence of Grid Density

F6 wbnp outboard pylon

F6 wbnp inboard pylon
Case 1: Influence of Grid Density

$\Delta C_D$ extrapolated

<table>
<thead>
<tr>
<th>Code</th>
<th>WB</th>
<th>WBNP</th>
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<tbody>
<tr>
<td>TAU</td>
<td>-2.3%</td>
<td>-2.4%</td>
</tr>
<tr>
<td>elsA</td>
<td>+1.0%</td>
<td>+0.9%</td>
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elsA (ICEM grids used; grids not suitable for grid refinement !)
Case 1: Flow Phenomena

→ Geometry influences trailing edge separation

Recirculation

Trailing edge separation

Flow around pylon
Case 1: Flow Phenomena

→ Geometry influences trailing edge separation

Recirculation

Trailing edge separation

Flow around pylon

Closed Trailing Edge
Case 1: Flow Phenomena
Case 1: Flow Phenomena

Separation
Case 1: Flow Phenomena
Case 1: Flow Phenomena
Case 2: Drag Coefficients
Case 2: Moment Coefficients
Case 3: Comparison with transition / fully turbulent

WB Exp.
WB TAU trans.
WB TAU turb.

WB
$\eta = 0.331$

WB
$\eta = 0.377$
Case 3: Comparison with transition / fully turbulent

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<tbody>
<tr>
<td>WB</td>
<td>287.4</td>
<td>282.1</td>
<td>5.3</td>
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<tr>
<td>WBNP</td>
<td>330.6</td>
<td>329.0</td>
<td>1.6</td>
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</tbody>
</table>
Case 3: Comparison with transition / fully turbulent

F6 wbnp nacelle 300 deg cut
Case 4: Mach Drag Rise
DLR-F6 Cases: Installation drag


<table>
<thead>
<tr>
<th>$C_{D-\text{Install.}}$</th>
<th>Exp.</th>
<th>TAU</th>
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<tbody>
<tr>
<td>L1 – L2</td>
<td>10.7</td>
<td>11.8</td>
</tr>
<tr>
<td>L2 – L3</td>
<td>3.0</td>
<td>2.3</td>
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Summary

• Hybrid method (TAU & Centaur) is able to predict drag for DLR-F6 within a range of 5-8% ($C_L=0.5$)

• Grid adaptations are necessary to reduce discretization errors

• Flow phenomena have to be computed correctly to ensure drag prediction

• Trailing edge geometry of DLR-F6 has an influence on wing upper side flow separations

• Wing lower side transition is of importance

• Drag differences of 1-2 $dc$ can be computed when errors are systematic

• Remaining questions: transition, trailing edge effects