FUN3D Analysis of DPW-III Wing Alone Configurations

Elizabeth M. Lee-Rausch, Chris L. Rumsey and Dana P. Hammond
NASA Langley Research Center

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FUN3D Unstructured Grid Code

- Parallel 3D compressible finite-volume RANS for tetrahedral meshes
- Implicit time-stepping using point Gauss-Seidel and line-relaxation for linear system
- Upwind Roe scheme for inviscid fluxes
- Galerkin-type approximation for viscous fluxes
- Full Navier-Stokes equations
- Spalart-Allmaras & SST turbulence models (loosely coupled)
FUN3D Unstructured Grid Code

• Parallel version
  – Pre-processor, flow solver and post-processor fully parallel
  – Domain decomposition using the MeTiS and ParMetis mesh partitioning software (weighted for the line solver)
  – Parallel code execution scheme utilizes MPI
Computational Grids – Wing Alone

- Workshop VGRIDns node-based grids (with the octree based spacing of Kania)
- VGRIDns 64-bit batch on columbia (Pirzadeh)

<table>
<thead>
<tr>
<th></th>
<th>Wing 1 Total Nodes</th>
<th>Wing 2 Total Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>1,806,422</td>
<td>1,882,672</td>
</tr>
<tr>
<td>Medium</td>
<td>4,476,969</td>
<td>4,658,853</td>
</tr>
<tr>
<td>Fine</td>
<td>11,459,041</td>
<td>11,903,329</td>
</tr>
<tr>
<td>Super Fine</td>
<td>36,900,028</td>
<td>38,462,630</td>
</tr>
</tbody>
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Summary FUN3D Results

- Case 2A: Mach 0.76, $\alpha=0.5\text{deg}$, $Re_c=5\times10^6$ (SA fully turbulent)
  - Wing 1 coarse, medium, fine and super fine grids
  - Wing 2 coarse, medium, fine and super fine grids
- Case 2B: Mach 0.76, $\alpha=0.5\text{deg}$, $Re_c=5\times10^6$ (SA fully turbulent)
  - Wing 1 medium grid polar
  - Wing 2 medium grid polar
Wing Alone Grid Refinement

Mach = 0.76
\( \alpha = 0.5 \text{deg} \)
Re\(_c\) = 5x10\(^6\)
Spalart-Allmaras
Fully Turbulent
Wing 1 Grid Refinement

Coarse Grid (1.8M)
Medium Grid (4.5M)
Fine Grid (11.5M)
Super Fine Grid (36.9M)
Wing 2 Grid Refinement

Coarse Grid (1.9M)
Medium Grid (4.7M)
Fine Grid (11.9M)
Super Fine Grid (38.4M)
Wing Alone Super-Fine Grid Skin Friction

Wing 1
$\alpha = 0.5\text{deg}$

Wing 2
$\alpha = 0.5\text{deg}$
Wing Alone Polar

Mach = 0.76
Re_c = 5x10^6
Spalart-Allmaras
Fully Turbulent
Wing 1 Skin Friction

$\alpha = -1.0\text{deg}$

$\alpha = 0.5\text{deg}$

$\alpha = 1.5\text{deg}$

$\alpha = 3.0\text{deg}$
Wing 2 Skin Friction

$\alpha = -1.0\text{deg}$

$\alpha = 0.5\text{deg}$

$\alpha = 1.5\text{deg}$

$\alpha = 3.0\text{deg}$
Summary

• Case 2A- W1
  – Drag and lift are decreasing with grid refinement
  – Small trailing edge separation on superfine grid
• Case 2A-W2
  – Drag and lift are decreasing with grid refinement
  – Small trailing edge separation on superfine grid
• Case 2B
  – Improved performance of W2 at design point
  – Both wing start to separate around $\alpha = 1.5\text{deg}$