FUN3D Analysis of DPW-III Wing/Body Configurations

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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/Body

- 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/Body Total Nodes</th>
<th>Wing/Body/Fairing Total Nodes</th>
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</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>5,354,214</td>
<td>5,618,073</td>
</tr>
<tr>
<td>Medium</td>
<td>14,298,135</td>
<td>14,598,610</td>
</tr>
<tr>
<td>Fine</td>
<td>40,014,934</td>
<td>41,069,036</td>
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</tbody>
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Summary FUN3D Results

• Case 1A: Mach 0.75, $C_L=0.5$, $Re_c=5\times10^6$ (SA fully turbulent)
  – Wing/body coarse, medium, and fine grids
  – Wing/body/fairing coarse, medium, and fine grids
• Case 1B: Mach 0.75, $C_L=0.5$, $Re_c=5\times10^6$ (SA fully turbulent)
  – Wing/body medium grid polar
  – Wing/body/fairing medium grid polar
Wing/Body Grid Refinement

Mach 0.75
$C_L = 0.5$
$Re_c = 5 \times 10^6$
Spalart-Allmaras
Fully Turbulent
Wing/Body Grid Refinement

- $\eta = 0.150$
- $\eta = 0.239$
- $\eta = 0.331$
- $\eta = 0.377$
- $\eta = 0.514$
- $\eta = 0.638$
- $\eta = 0.847$

F6 Coarse Grid (5.4M)
F6 Int. Grid (14.3M)
F6 Fine Grid (40.0M)
Wing/Body/Fairing Grid Refinement

F6FX2B Coarse Grid (5.4M)
F6FX2B Int. Grid (14.5M)
F6FX2B Fine Grid (41.1M)
Wing/Body Fine Grid
Streamlines & Skin Friction

F6

F6FX2B
Wing/Body Polar

Mach 0.75  
Re$_c$ = $5 \times 10^6$  
Spalart-Allmaras  
Fully Turbulent
Summary

• Case 1A- F6
  – Drag is increasing with grid refinement
  – Significant wing/root juncture separation
  – Trailing edge separation

• Case 1A-F6FX2B
  – Drag is decreasing with grid refinement
  – No wing/root juncture separation
  – Trailing edge separation

• Case 1B
  – Improved performance with fairing over range of angles of attack