Overset Grids for the NASA CRM WB & WBNP Aero-Elastic Configurations

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Outline: Baseline Overset Grids

- Grid Family Numerology
- Grid Topology
- Grid Generation Process
- Grid Images
- Grid Metrics
- Errata

ftp://cmb24.larc.nasa.gov/outgoing/DPW6/overset_grids_Boeing_Serrano.REV00/
Grid Family Numerology (1/2)

- A requirement for approximately 1.5 X growth from one level to the next finer level was specified by the committee.

- Since the cube root of 1.5 ~ 1.15 ~ (8/7), this ratio was used to establish the growth between the Fine and X-Fine levels.

- All grid segments in the coarse grid were factors of 5 x N where N is an even integer.
  - For example, the wing airfoil has a total of 240 cells, with 110 on upper and lower surfaces and 20 on the TE base.
Grid Family Numerology (2/2)

- Coarse Grid Generated First
- Family Generated using Following Factors

<table>
<thead>
<tr>
<th>Level</th>
<th>Cell Dim</th>
<th>Growth Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiny</td>
<td>$4 \times N$</td>
<td>$(5/4)^3 = 1.953$</td>
</tr>
<tr>
<td>Coarse</td>
<td>$5 \times N$</td>
<td>$(6/5)^3 = 1.728$</td>
</tr>
<tr>
<td>Medium</td>
<td>$6 \times N$</td>
<td>$(7/6)^3 = 1.588$</td>
</tr>
<tr>
<td>Fine</td>
<td>$7 \times N$</td>
<td>$(8/7)^3 = 1.493$</td>
</tr>
<tr>
<td>eXtra-Fine</td>
<td>$8 \times N$</td>
<td>$(9/8)^3 = 1.424$</td>
</tr>
<tr>
<td>Ultra-Fine</td>
<td>$9 \times N$</td>
<td></td>
</tr>
</tbody>
</table>

Where $N$ is an even integer
Grid Topology

The following wireframes illustrate zone topologies employed
(WBNP zones = 25; WB zones = 8)
The grid generation process employed is based on two key cornerstones: ICEMCFD HEXA and NASA’s Chimera Grid Tools (CGT), providing a high degree of automation.

**ICEMCFD 2D HEXA**
- Used to generate all body fitted surface grids projected to geometry
- Used to generate the box volume grids

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NASA’s Chimera Grid Tools (CGT)

- Used config.tcl to manage configuration zones
- Used inputs.tcl to specify volume grid generation and grid coupling parameters
  - BUILDVOL Used to generate body fitted volume grids
  - BUILDPEG5i Used to hole-cut and couple grid

Additionally, custom TCL scripts based on CGT’s scriptlib and ICEM replay files were used throughout the process
WBNP (ae2.75)

- Manually created 2D HEXA blocking files for each body fitted grid
- Used custom TCL script to generate the family of WBNP grids
  - Automatically scaled number of points and end spacings on HEXA blocking file to generate new surface grids
  - Automatically ran BUILDVOL and BUILDPEG5i with appropriate scaling factors (e.g., offset, viscous spacing)

WB (ae2.75) Grid Family Created from WBNP Grids

- TCL script extracted applicable volume zones and ran BUILDPEG5i

WB Deflected Medium Grid Models

- Manually updated blocking file on each deflected geometry
  - Minimal effort; process could have been scripted
Mesh Images (1/3)

Medium Grid
Mesh Images (2/3)

Medium Grid

Nacelle Duct

Wingtip

TE Close-Up

LE Close-Up
Mesh Images (3/3)

Medium Grid

WB Collar

Wing O-Mesh

TE Close-Ups
## Nominal values for body fitted volume grids

<table>
<thead>
<tr>
<th>Grid</th>
<th>Viscous Spacing</th>
<th>$\sim y^+$</th>
<th># Constant Cells at Wall</th>
<th>Maximum Stretching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiny</td>
<td>0.001478</td>
<td>1.02</td>
<td>4</td>
<td>1.235</td>
</tr>
<tr>
<td>Coarse</td>
<td>0.001182</td>
<td>0.80</td>
<td>5</td>
<td>1.186</td>
</tr>
<tr>
<td>Medium</td>
<td>0.0009853</td>
<td>0.67</td>
<td>5</td>
<td>1.149</td>
</tr>
<tr>
<td>Fine</td>
<td>0.0008446</td>
<td>0.58</td>
<td>6</td>
<td>1.128</td>
</tr>
<tr>
<td>X-fine</td>
<td>0.0007390</td>
<td>0.50</td>
<td>7</td>
<td>1.112</td>
</tr>
<tr>
<td>U-fine</td>
<td>0.0006569</td>
<td>0.45</td>
<td>8</td>
<td>1.099</td>
</tr>
</tbody>
</table>
## Grid Metrics (2/3)

**WB (ae2.75) Grid Family: 8 zones**

<table>
<thead>
<tr>
<th>Grid</th>
<th>Grid Points</th>
<th>Orphans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiny</td>
<td>7,398,176</td>
<td>0</td>
</tr>
<tr>
<td>Coarse</td>
<td>14,355,678</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>24,698,828</td>
<td>0</td>
</tr>
<tr>
<td>Fine</td>
<td>39,098,858</td>
<td>0</td>
</tr>
<tr>
<td>X-fine</td>
<td>58,227,000</td>
<td>0</td>
</tr>
<tr>
<td>U-fine</td>
<td>82,754,486</td>
<td>0</td>
</tr>
</tbody>
</table>

U-fine/Tiny ~ 11.2 X
Grid Metrics (3/3)

WBNP (ae2.75) Grid Family: 25 zones

<table>
<thead>
<tr>
<th>Grid</th>
<th>Grid Points</th>
<th>Orphans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiny</td>
<td>11,865,177</td>
<td>5</td>
</tr>
<tr>
<td>Coarse</td>
<td>22,999,565</td>
<td>6</td>
</tr>
<tr>
<td>Medium</td>
<td>39,542,953</td>
<td>3</td>
</tr>
<tr>
<td>Fine</td>
<td>62,566,221</td>
<td>3</td>
</tr>
<tr>
<td>X-fine</td>
<td>93,176,522</td>
<td>4</td>
</tr>
<tr>
<td>U-fine</td>
<td>132,381,764</td>
<td>1</td>
</tr>
</tbody>
</table>

WBNP/WB ~ 1.6 X
Family Surface Grid Density Variation

Model ae2.75

Tiny → Coarse → Medium

U-fine ← X-fine ← Fine
Grid Errata re “Rev00” (1/2)

Wingtip TE Cap Region

ae3.00 & ae3.50

Failed to smooth topology corners

Updated Grid “Rev01”

(ae3.50 shown)

L=15  

L=15
Grid Errata re “Rev00” (2/2)

**Wing TE Break (ae3.50)**
Failed to project block vertex to correct geometry point, creating micro lip at lower surface

**Updated grid “Rev01”**
Problem occurred by failing to update block vertex-point association

Vertical distance offset at the one affected surface grid point ~ 0.017"
Thank You!