Applied Research Group
Seeking Answers, Deploying Solutions

Intelligent Light
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Intelligent light

HI LIFT PREDICTION WORKSHOP 2
Outline

• Purpose
  – IL’s contribution to the knowledge base
  – Get current with OVERFLOW and CFD pain (I’ve been in management & teaching too long …)
  – Create demonstration cases for our own Applied Research Group projects

• Demonstrate Large scale big data post processing and effective workflow processes

• Provide a different method to the community
AIAA High Lift Prediction Workshop

• **Case 1**
  - Coarse, medium, fine and extra fine grid
  - SA Turbulence model
  - Alpha – 7, 16, 18.5, 20, 21, 22.4
  - Steady
  - Blind Run up to 2600 Steps (Still Running…)

• **Case 2**
  - Medium grid
  - High Reynolds
    - Alpha – 0, 7, 12, 16, 18.5, 20, 21, 22.4
    - SA Turbulence Model
    - Fully Turbulent
    - Blind Run Up to ~10k Steps
  - Low Reynolds
    - SA Turbulence Model
    - Fully Turbulent (Blind Run Up to ~10k Steps)
    - Transition (Menter-Langtry) (In progress)
    - k-W-SST (In progress)
    - k-W-SST Unsteady (In progress)
OVERFLOW and FV Workflows

• Solver - OVERFLOW-2.2e
  – Cray XE6
  – 128-1024 cores (75-85% // Efficiency)
  – Methodologies
    • RHS - Roe upwind
    • LHS – Scalar Penta
    • Full Multi-Grid
    • Full Viscous Terms

• FieldView 13.2 & 14-beta
  – Cray XE6 – 16 cores
  – Automated Batch Post-Processing
  – XDB workflow for surface data extraction
  – FVX + gnuplot for 2D plotting
  – Multi-Window Comparisons
Issue with Large Scale Post-Processing

• Writing, reading or copying large results files takes a long time
  – Wastes engineering time
  – Important data is quite small
• Slow network speed
  – Performance is often unpredictable
• Sharing large results files takes much space and time
• Analyzing many datasets requires repeating many steps
• Graphics hardware outpacing software development
• Data Extracts – XDB Workflows
Volume Data Processing…

**Volume Data**

**READ**

**CREATE**

**Post-processing Objects**

**POSTPROCESS**

**Actions on Objects:**
- Visualize/Render
- Animate/Sweep Cache
- Integrate Forces
- Probe/plot values
- Output Pics/movies

**Compute Objects:**
- Geometry
- Cutting Planes
- Iso-surfaces
- Streamlines

**WRITE**

**XDB File**
...to XDB Workflows

XDB File

Post-processing Objects

Actions on Objects:
- Visualize/Render
- Animate/Sweep Cache
- Integrate Forces
- Probe/plot values
- Output Pics/movies

READ/APPEND

CREATE

POSTPROCESS

Compute Objects:
- Geometry
- Cutting Planes
- Iso-surfaces
- Streamlines

READ/APPEND

XDB File

- Full Numerical Fidelity
- Normals included
- Smaller files (10X-100X)
- Lower memory (10X-100X)
HiLiftPW 2 General Workflow

- Run the OVERFLOW2 case 128 – 1056 processors
- Submit post processing job, 16 procs in batch directly on remote Cray XE6 system
  - Boundary Surface Extracts
  - Coordinate cut planes
  - Velocity Profiles
  - Surface Streamlines
- Create images, tables and 2D plots
  - Perform all on the big iron especially if good graphics connected to system or …
  - Move extracts and solver output to local workstation
## XDB Data reduction

### Case 1

<table>
<thead>
<tr>
<th>Grid Size</th>
<th># Overset Grids</th>
<th>Grid Points (10^6)</th>
<th>Grid File Size</th>
<th>Soln File Size</th>
<th>Coordinate Cut Plans (3 planes) 7 scalars</th>
<th>Boundary Surface 12 scalar variables</th>
<th>Surface Streams Medium seed density, 2 variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>44</td>
<td>29.4</td>
<td>758M</td>
<td>1.6G</td>
<td>14.1M</td>
<td>24M</td>
<td>435M</td>
</tr>
<tr>
<td>Medium</td>
<td>44</td>
<td>69.0</td>
<td>1.8G</td>
<td>3.6G</td>
<td>25.8M</td>
<td>41M</td>
<td>411M</td>
</tr>
<tr>
<td>Fine</td>
<td>44</td>
<td>230.7</td>
<td>6.1G</td>
<td>13G</td>
<td>58M</td>
<td>92M</td>
<td>524M</td>
</tr>
<tr>
<td>Extra-Fine</td>
<td>44</td>
<td>544.5</td>
<td>15G</td>
<td>29G</td>
<td>98M</td>
<td>160M</td>
<td>530M</td>
</tr>
</tbody>
</table>
Force and moments

Case 1 - AoA vs. CL

Case 1-CL vs. CD

Case 2 - AoA vs. CL

Case 2 - CL vs. CD
Surface Coefficients

- Extract - Boundary Surface
  - Slat, Main, Flap, Body
  - Cp, Cf, Cfx, Cfy, Cfz, Surface Normals
- Further processed on local workstation
- Take slices at the pressure stations
  - Use thresholding on the provided workshop equations and find cell center of resulting polygon
  - Output 2D plot data to standard formats
- Automatically create multi plot comparisons using your favorite 2d Plot program (i.e. Gnuplot)
Case 1 – Grid Refinement Effect @ 7, 18.5, 21, 22.4 Degrees
Case 1 High Lift Prediction Workshop

Alpha = 7
Grid Density = coarse
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 7
Grid Density = medium
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 7
Grid Density = fine
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop

Alpha = 7
Grid Density = extrafine
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop

Alpha = 18.5
Grid Density = coarse
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop

Alpha = 18.5
Grid Density = medium
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 18.5
Grid Density = fine
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 18.5
Grid Density = extrafine
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 21
Grid Density = coarse
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop

Alpha = 21
Grid Density = medium
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop

Alpha = 21
Grid Density = fine
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 21
Grid Density = extrafine
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 22.4
Grid Density = coarse
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop

Alpha = 22.4
Grid Density = medium
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop

Alpha = 22.4
Grid Density = fine
Experiment = RUN238_Re=15.1e6
Case 1 High Lift Prediction Workshop
Alpha = 22.4
Grid Density = extrafine
Experiment = RUN238_Re=15.1e6
Case 2 – High and Low Reynolds Number Effect @ 7, 18.5 & 21 Degrees
Case 2 High Lift Prediction Workshop
Alpha = 7
Grid Density = medium
Experiment = RUN238_Re=15.1e6
Case 2 High Lift Prediction Workshop

Alpha = 7  
Grid Density = medium  
Experiment = RUN29293_Re=1.35e6
Case 2 High Lift Prediction Workshop
Alpha = 18.5
Grid Density = medium
Experiment = RUN238_Re=15.1e6
Case 2 High Lift Prediction Workshop
Alpha = 18.5
Grid Density = medium
Experiment = RUN29293 Re=1.35e6
Case 2 High Lift Prediction Workshop
Alpha = 21
Grid Density = medium
Experiment = RUN238_Re=15.1e6
Case 2 High Lift Prediction Workshop
Alpha = 21
Grid Density = medium
Experiment = RUN29293_Re=1.35e6
Velocity comparisons

- Line Plot Extractions
- Directly sample and export velocity plot data to disk
  - Experiment vs Case 1 coarse to exfine
  - Experiment vs Case2 Reynolds number
Experiment vs Case 1

Velocity Profiles
Hi Reynolds
7, 18.5, 21 Degrees
Effect of Grid Refinement coarse, medium, fine, extra-fine
Velocity profiles 7 Deg. – Hi Rey
Velocity profiles 18.5 Deg. – Hi Rey
Velocity profiles 21 Deg. – Hi Rey
Experiment vs Case 2

Effect of Reynolds Number
7, 18.5, 22.4 m/s
Velocity profiles 7 Deg. – Case 2

- P1 WB L1
- P1 WB L2
- P1 wC L1
- P1 wD L1
- P2 wb L1
- P2 wb L2
- P2 wD L1
- P2 wE L1
- P2 wE L2
- P3 wE L1
- P3 wE L2
Velocity profiles 18.5 Deg. – Case 2
Velocity profiles 21 Deg. – Case 2
Surface streamlines

- Create surface streamlines using Surface Flow Tool
- Execute script based upon FVX -> .fvp files
- Download the resulting pathline file
- Load in to interactive session for exploration or batch process direct to images
Case 2 Low Reynolds
Summary

• Trending similar to others
• Flow separation of interest
• Unsteady, Turbulence, Convergence?
• Saga Continues
  – Continuing to “run out” solutions across the board
  – Look at transition and unsteady cases more carefully
  – Would like to do AMR
• What have I (re)learned
  – Pay attention to Convergence
  – May be use pre-conditioning
  – Need a structured grid that to enables better load balancing (AMR?)
  – Unsteady needs attention
Future Work

• Run out Case 1
• Run out Case 2
  – High Reynolds
    • Run to Convergence
    • Off Body Flows
  – Low Reynolds
    • Transition (Menter-Langtry) (Finish)
    • k-W-SST (finish)
    • k-W-SST Unsteady (finish)

• XDB Workflow Case Study – July 2013
• AIAA Summer 2014 Paper