BSCW Test Case

Presented by:

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Benchmark Supercritical Wing (BSCW)

- Simple, rectangular wing
- Data acquired under mixed attached/separated flow conditions

Known deficiencies:
- Limited number of pressure transducers in experimental data
- Limited number of discrete frequencies of oscillation
- Mach number is at edge of acceptable range for quality pressure data with splitter plate

M=0.85, Re_c=4.49 million, test medium: R-134a

a) Steady Case
   i. $\alpha = 5^\circ$

b) Dynamic Cases
   i. $\alpha = 5^\circ$, $\theta = 1^\circ$, $f = 1$ Hz
   ii. $\alpha = 5^\circ$, $\theta = 1^\circ$, $f = 10$ Hz
CFD and Aeroelastic Analysis
http://fun3d.larc.nasa.gov/

- Solves 2D/3D steady and unsteady Euler and RANS equations on node-based mixed element grids for compressible and incompressible flows
- Supports numerous internal/external efforts across speed range
- General dynamic mesh capability: any combination of rigid/overset/morphing grids, including 6-DOF effects
- Aeroelastic modeling w/ mode shapes, full FEM
- Constrained/multipoint adjoint-based design and mesh adaptation
- Modern software practices including 24/7 testing
- Linear scaling through thousands of cores
- Capabilities fully integrated, very responsive support team, online documentation, training videos, tutorials, etc

Propulsion Effects
Morphing Vehicles
Low-Speed Flows
BMI Corporation
Reacting Flows
Supersonics
US Army
Launch Vehicles
Rotorcraft
FUN3D Analysis

- FUN3D v.11.6
- Roe scheme
- Venkatakrishnan flux limiter
- SA turbulence model
- Mixed element grids: created by Pawel Chwalowski using VGRID

Coarse Grid: 2968550 nodes
Medium Grid: 9005346 nodes
Fine Grid: 26786862 nodes
FUN3D Analysis
Convergence

BSCW, AOA=5deg, Medium Grid, CL, CD

BSCW, AOA=5deg, Fine Grid
FUN3D Analysis
Convergence

Wing Lift and Drag vs. Grid Factor

Pitching Moment vs. Grid Factor
### BSCW Dynamic Cases Computational Matrix

**1Hz Case**

<table>
<thead>
<tr>
<th>Time</th>
<th>Grid</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$dt / dn / N$</td>
<td>$dt / dn / N$</td>
<td>$dt / dn / N$</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>0.0078 / 128 / 8</td>
<td>0.0078 / 128 / 8</td>
<td>0.0078 / 128 / 8</td>
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<tr>
<td>2</td>
<td></td>
<td>0.0039 / 256 / 8</td>
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<tr>
<td>3</td>
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<td>0.00098 / 1024 / 2</td>
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**10Hz Case**

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<td>0.00078 / 128 / 4</td>
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*dt: timestep size (seconds)  
dn: # of timesteps per cycle  
N: # of cycles

Analyses not completed

Note:  
1. 25 subiterations per time step  
2. Solutions were run for 2 cycles before unsteady surface pressure was collected
# BSCW Dynamic Cases Computational Matrix

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## 10Hz Case

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Mean $C_p$ Upper and Lower
Unsteady $f=1$Hz Magnitude and Phase
Unsteady f=10Hz Magnitude and Phase

BSCW, 10Hz, Upper Surface

BSCW, 10Hz, Lower Surface
Animations
BSCW, 1Hz
BSCW, 1Hz, Mach Contours, Medium Grid/256 time steps per cycle
Summary

• BSCW is a simple geometry and a more complex flow physics case for AePW than RSW

• This a ‘semi-blind’ with some experimental data published before

• Steady state solutions show an oscillatory behaviour

• Turbulence model and subiteration convergence effects on solution needs to be further investigated

• Experimental pressure tabs resolution needs to be addressed