AePW-1 BSCW test cases

A. Gehri and D. Steiling
RUAG Aviation
Who we are

RUAG Aviation, Department Aerodynamics
- Operates two subsonic wind tunnels
  - Large Wind Tunnel Emmen (LWTE), 7x5m, aerospace (powered/unpowered), full scale automotive rain testing
  - Automotive Wind Tunnel Emmen (AWTE), 2.45x1.55m, with road simulation
- Manufactures wind tunnel balances for other wind tunnels
- CFD in collaboration with CFS Engineering at the EPFL (Swiss Federal Institute of Technology) in Lausanne

Alain Gehri
- Experienced CFD engineer, within AePW responsible for meshing and setup of calculations

Daniel Steiling
- Aerodynamic engineer, within AePW responsible for coordination and post-processing
NSMB flow solver and settings

- Multiblock Navier-Stokes solver, hence the name “NSMB”
- Developed at the EPFL in Lausanne since 1991, together with other universities and industrial partners
- Settings used for the BSCW test cases:
  - Space discretization: 4th-order central scheme (Jameson)
  - Time integration: implicit LU-SGS scheme
  - Unsteady calculations: dual time stepping, w/ time correction procedure
  - Turbulence model: SA (URANS, RANS for static)
- Particular version of NSMB had a bug in the ALE formulation
  - Dissipation for the turbulent equations was wrong, grid velocity not included
  - Corrected now, see HIRENASD presentation
Test case specific settings and assumptions

- Cases calculated: static steady (c/m/f) -> dynamic(m), each with forced transition (7.5% U/L)
- Time steps per period
  - 128 for 1Hz case (64 was not sufficient, switch after 2 periods)
  - 64 for 10Hz case
- Six (10Hz case) / 2+5 (1Hz case) periods have been simulated, with the last four periods used to determine the FRF

\[ FRF = \frac{\text{fft}(\text{exitation}) \cdot \text{fft}(\text{response})}{\text{fft}(\text{extation}) \cdot \text{fft}(\text{extation})} \]
Grid overview
Grid convergence static case
Global picture
Global coefficients 1Hz case

\[ CX, CZ, C_{M\theta} = \frac{CZ_{avg}}{C_{M\theta_{avg}}} \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>( CX_{avg} )</td>
<td>0.072825</td>
</tr>
<tr>
<td>( CX_{avg}/\theta )</td>
<td>0.012341</td>
</tr>
<tr>
<td>( CZ_{avg} )</td>
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<tr>
<td>( CZ_{avg}/\theta )</td>
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<td>( C_{M\theta_{avg}} )</td>
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<td>( C_{M\theta_{avg}}/\theta )</td>
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<td>( C_{M\theta_{avg}}/\phi )</td>
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<td>( C_{M\theta_{avg}/\phi} )</td>
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<tr>
<td>( C_{M\theta_{phase}} )</td>
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<tr>
<td>( C_{M\theta_{phase}}/\phi )</td>
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</tr>
</tbody>
</table>
Global coefficients 10Hz Case
Cp at 60% station for 1Hz Case
Cp at 60% station for 10Hz Case
Cp time resolved 1Hz case
Cp time resolved 10Hz case
Issues encountered & challenges

- Convergence issues with static calculations, high number of iterations needed, residual oscillation (in Drag Counts) comparatively high
- Number of time steps per period?
- Shock magnitude large than in experiment, also out of phase (visible on imaginary part of cp FRF)
Thank you for your attention!

Questions?