AePW-1 BSCW test cases

A. Gehri and D.Steiling

RUAG Aviation

Together ahead. RUAG

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

Together ahead. RUAG

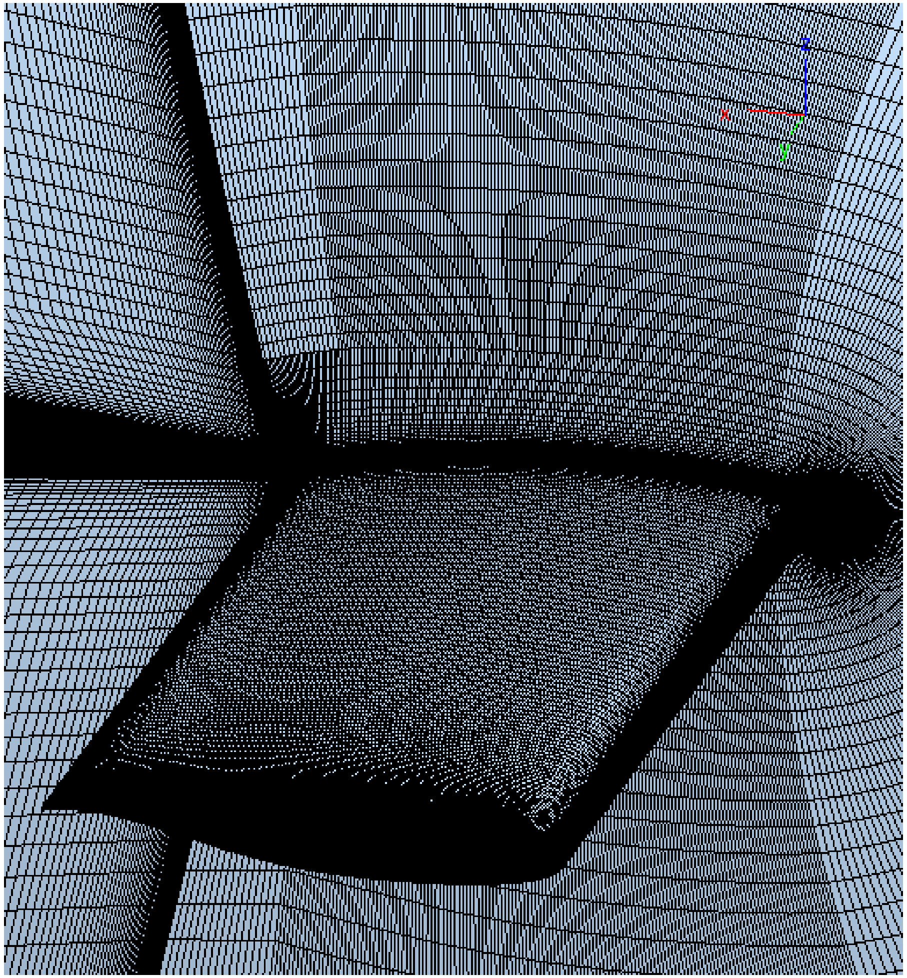
NSMB flow solver and settings

- 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

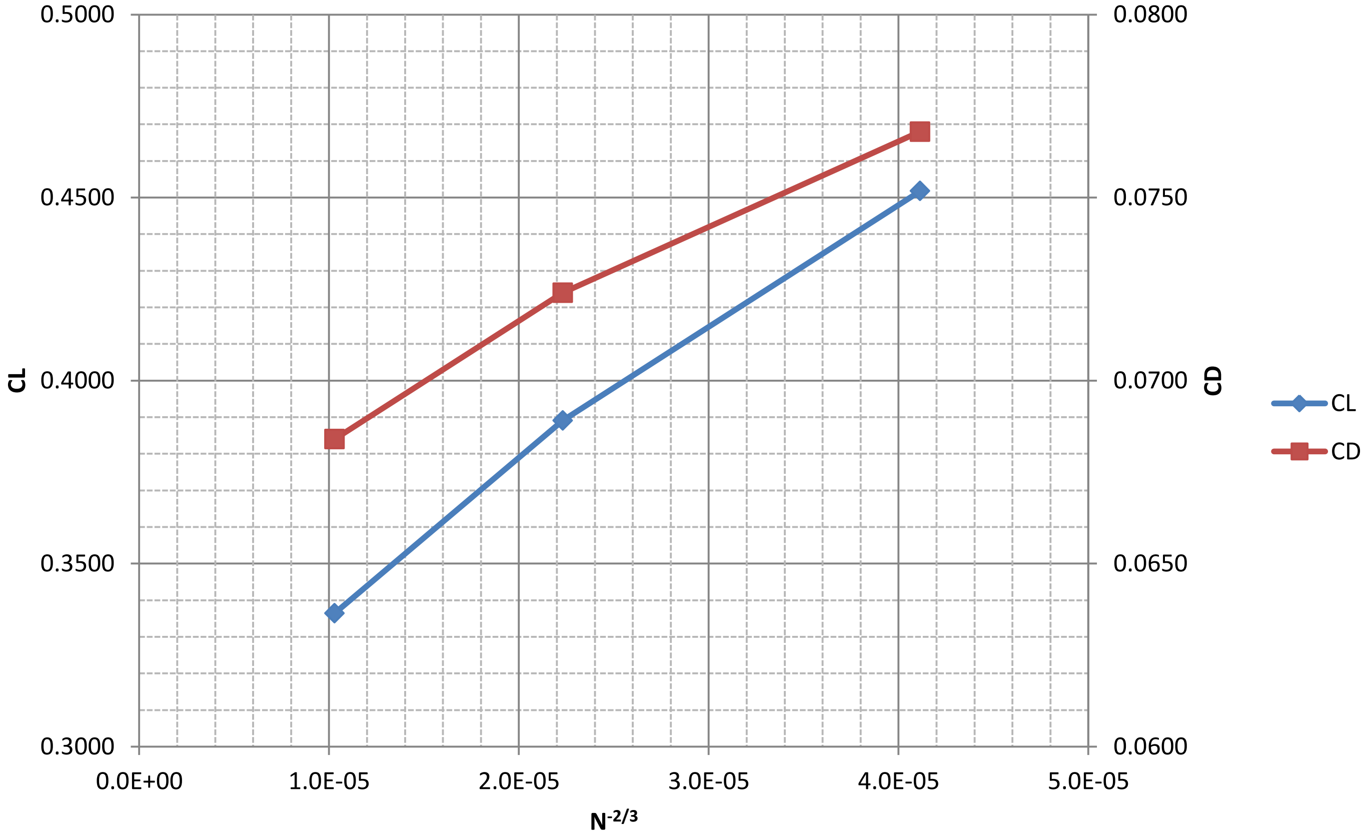
- Cases calculated: static steady (c/m/f) -> dynamic(m) , each with forced transition (7.5% U/L)
- Time steps per period
  - 128 for 1Hz case (64 was not sufficient, switch after 2 periods)
  - 64 for 10Hz case
- Six (10Hz case) / 2+5 (1Hz case) periods have been simulated, with the last four periods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

Grid overview



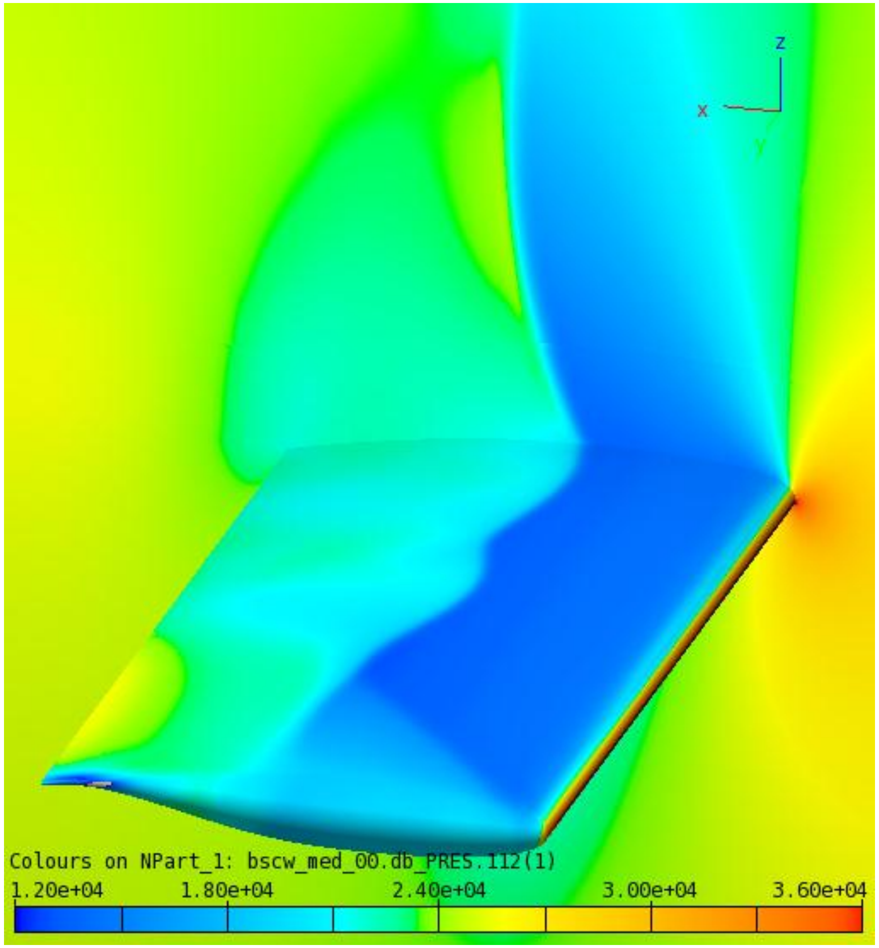
Together ahead. RUAG

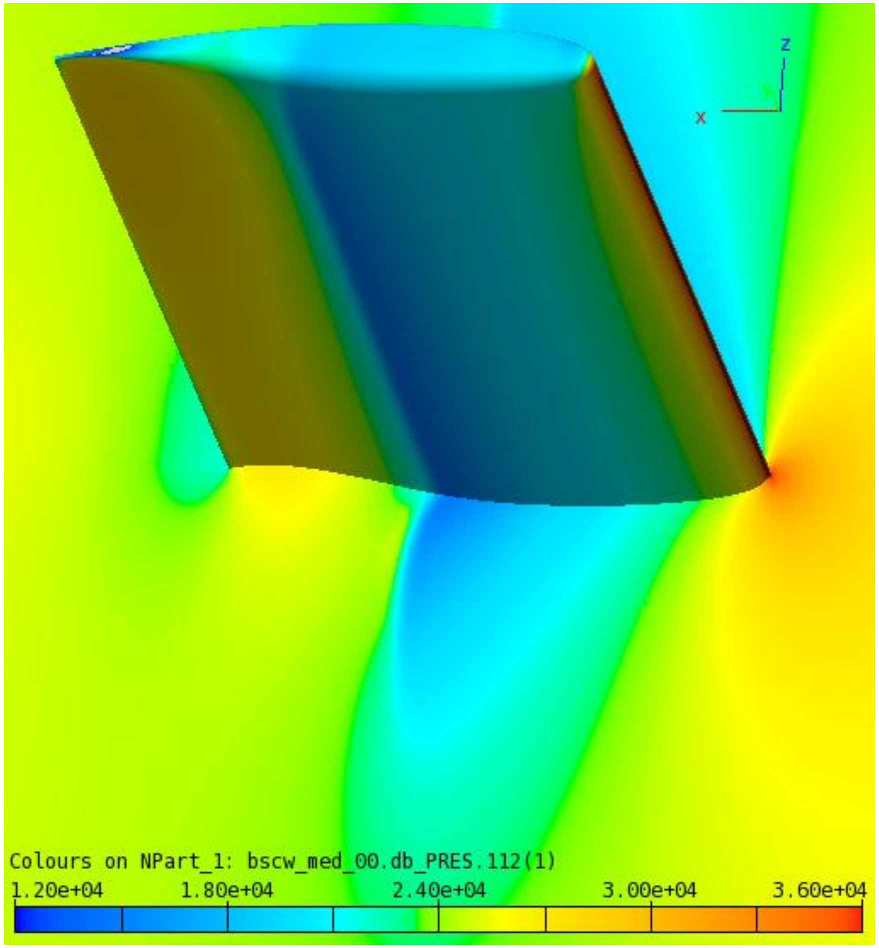
Grid convergence static case



Together ahead. RUAG

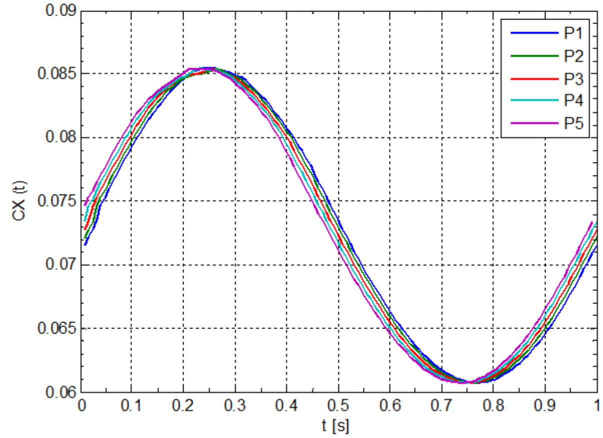
Global picture

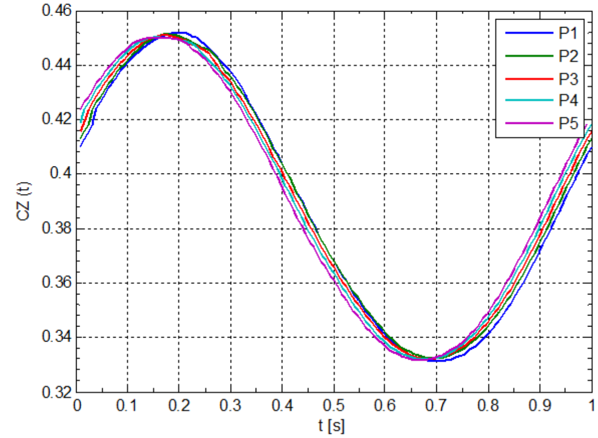


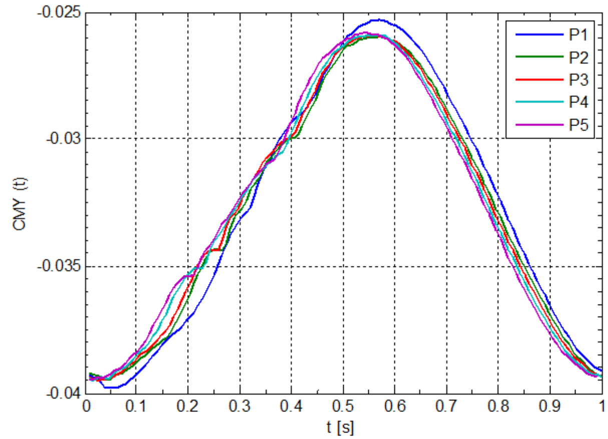


Together ahead. RUAG

Global coefficients 1Hz case





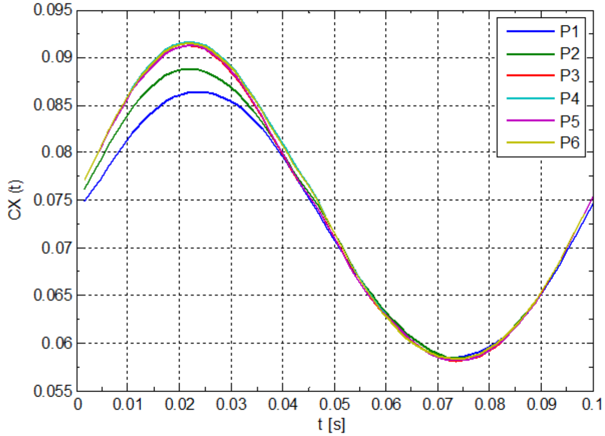


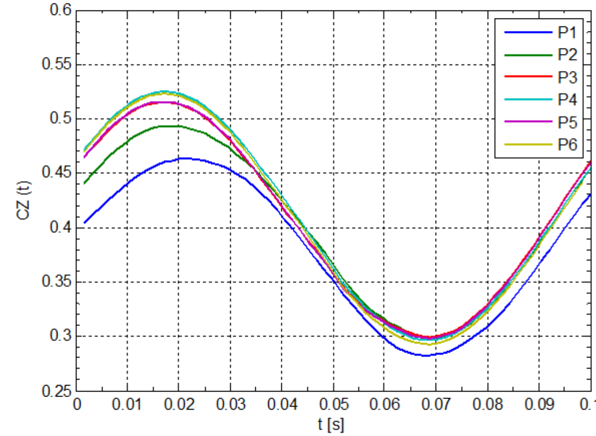
BSCW-f01Hz (1Hz)

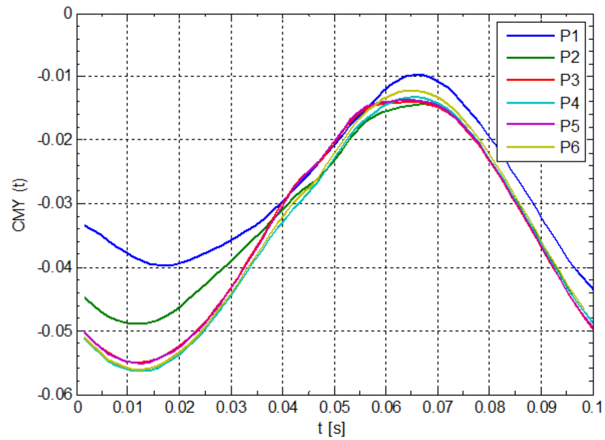
CX_{avg} = 0.072825	CZ_{avg} = 0.39046	CMY_{avg} = -0.032814
CX_{re}/θ = 0.012341	CZ_{re}/θ = 0.053395	CMY_{re}/θ = -0.0016569
CX_{im}/θ = 0.00042247	CZ_{im}/θ = 0.026052	CMY_{im}/θ = -0.0063033
CX_{mag}/θ = 0.012349	CZ_{mag}/θ = 0.059411	CMY_{mag}/θ = 0.0065174
CX_{phase} = 1.9606	CX_{phase} = 26.0086	CMY_{phase} = -104.7277

Together ahead. RUAG

Global coefficients 10Hz Case



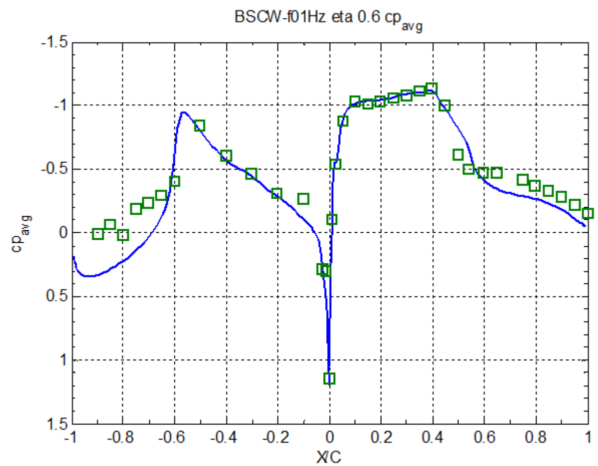


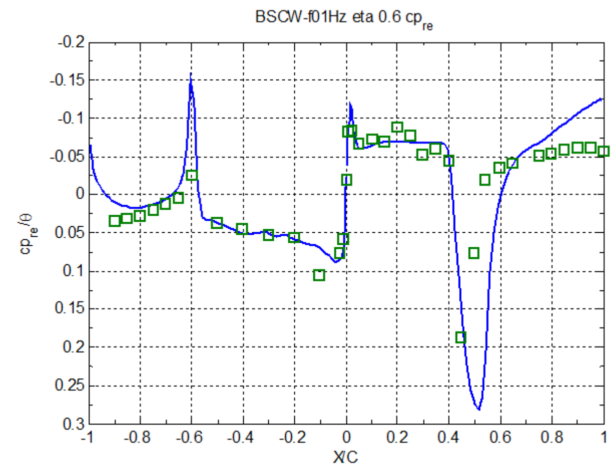


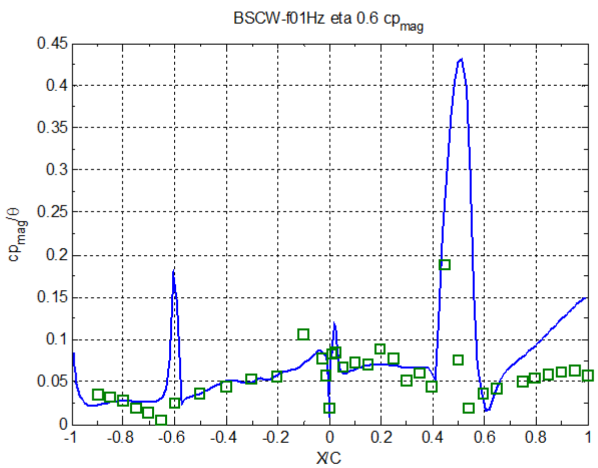
BSCW-f10Hz (10Hz)

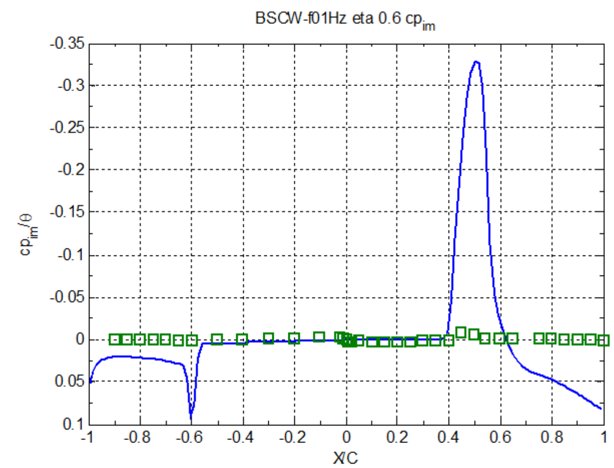
CX_{avg} = 0.073907	CZ_{avg} = 0.4073	CMY_{avg} = -0.034099
CX_{re}/θ = 0.016312	CZ_{re}/θ = 0.099288	CMY_{re}/θ = -0.015674
CX_{im}/θ = 0.0022952	CZ_{im}/θ = 0.049493	CMY_{im}/θ = -0.014206
CX_{mag}/θ = 0.016473	CZ_{mag}/θ = 0.11094	CMY_{mag}/θ = 0.021154
CX_{phase} = 8.0093	CX_{phase} = 26.4951	CMY_{phase} = -137.8133

Cp at 60% station for 1Hz Case

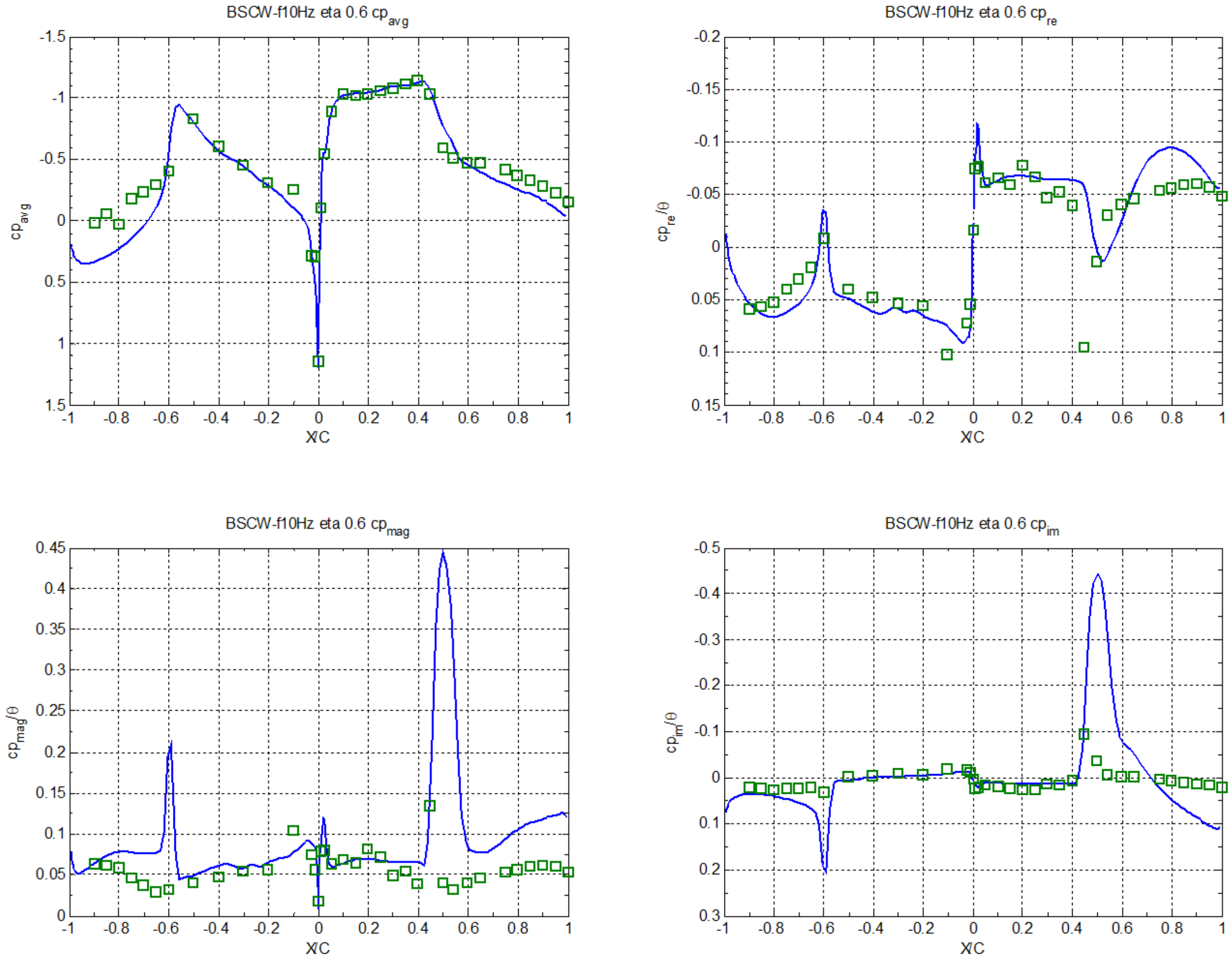






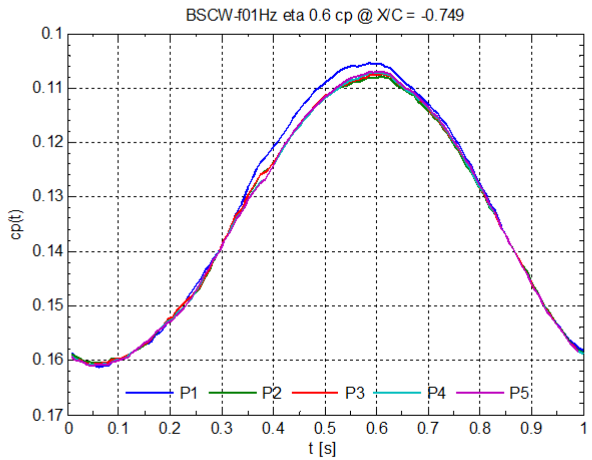


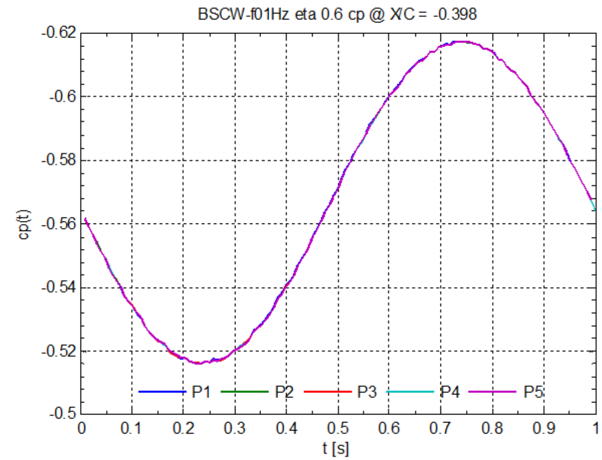
Cp at 60% station for 10Hz Case

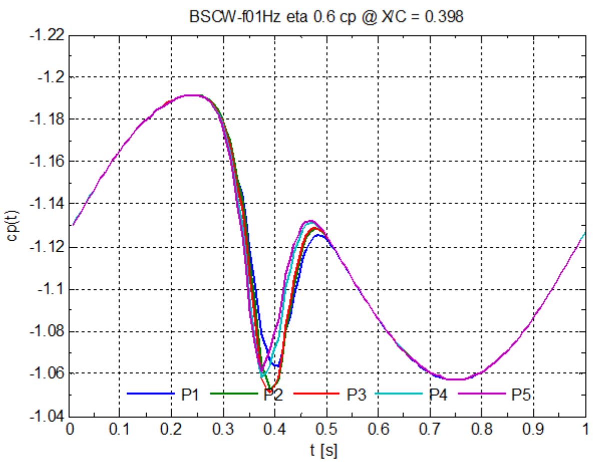


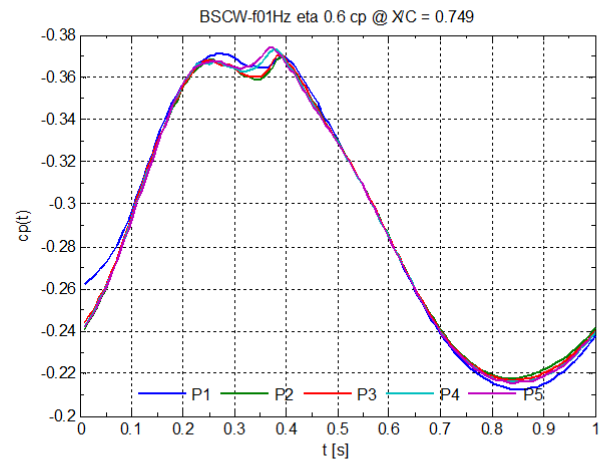
Together ahead. RUAG

Cp time resolved 1Hz case

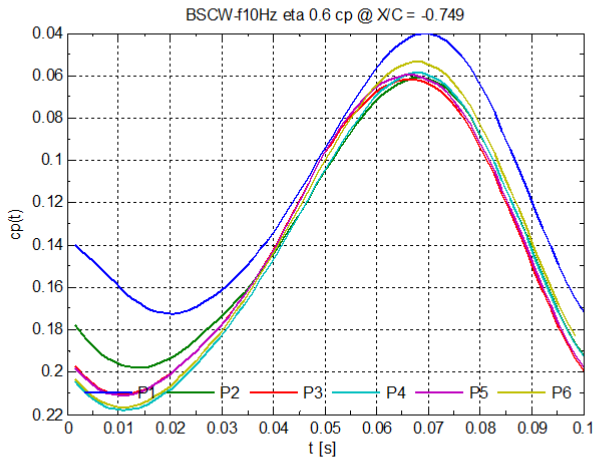


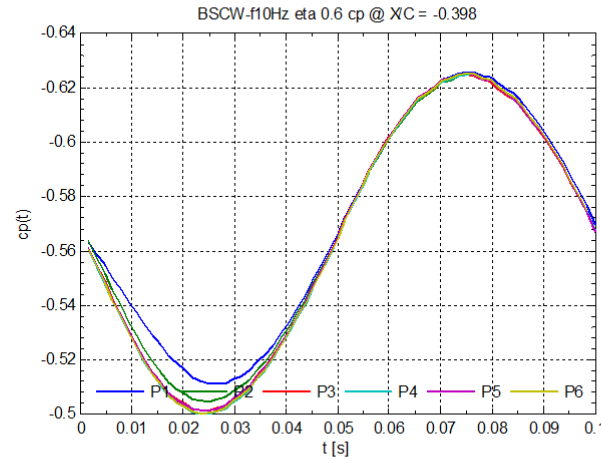


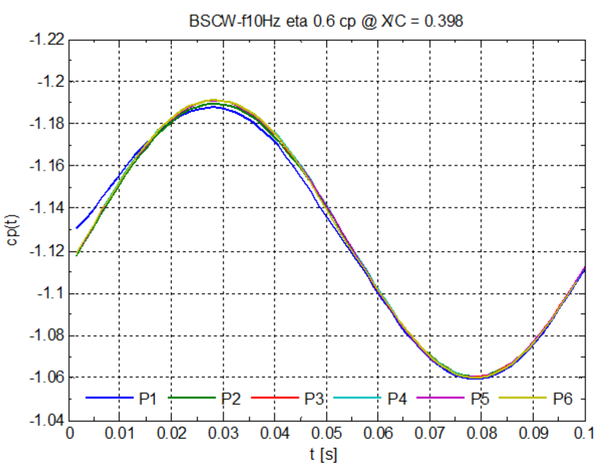


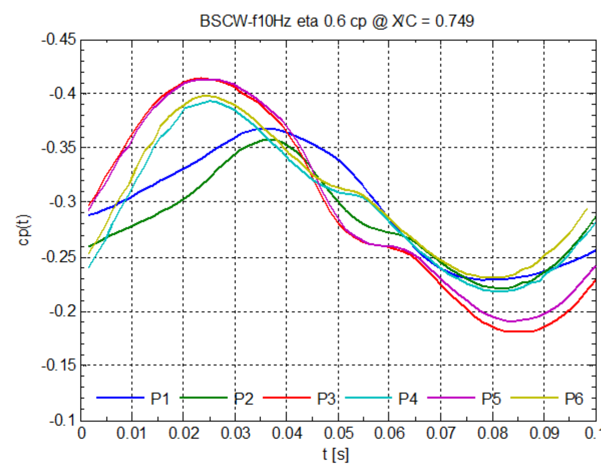


Cp time resolved 10Hz case









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?