

DPW-8/AePW-4

Test Case Summary

Static Deformation Working Group

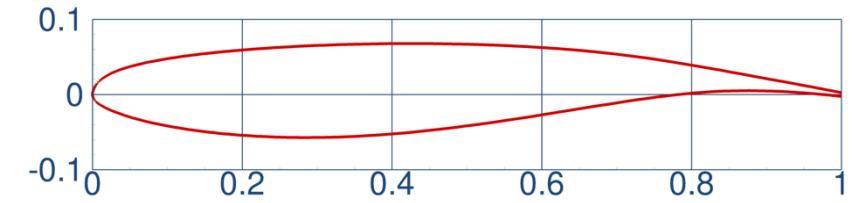
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- **Test Case 1a: ONERA OAT15A Airfoil (Transonic 2D)**
 - Purpose: Workshop-wide assessment of current state of scatter
- **Test Case 1b: FEM Validation**
 - Purpose: Validate FEM compared to physical model
- **Test Case 2a(E)/2b(E): NASA CRM Wing/Body (Transonic 3D)**
 - Purpose: Coupled FSI simulations starting from undeformed (jig) shape
- *Test Case 4a(E)/4b(E): NASA CRM Wing/Body/Nacelle/Pylon (Transonic 3D)*
 - *Purpose: Coupled FSI simulations with increased geometric complexity*

Test Case 1a: Workshop-Wide Validation

- Validation of steady CFD analysis, required
- Users are encouraged to employ best practices
- **Settings**
 - Steady CFD (e.g., RANS)
 - Prefer some version of SA, multiple turbulence models can be submitted
 - Purely 2D simulations (one cell wide)
- **Grids**
 - Six-member RANS grid family; four are required, six are desirable
 - Encourage use of committee-supplied grids; user-generated grids are acceptable
 - Committee-supplied grid is one cell wide with a 230mm chord (same as experiment) and follows RANS best practices
- **Conditions**
 - Mach 0.73, $Re_c=3m$ (based on chord length), $T_{static}= 271$ K (487.8 R)
 - Alpha: 1.36, 1.50, 2.50, 3.00, 3.10



ONERA OAT15A Transonic Airfoil

Jaquin, et al. "Experimental Study of Shock Oscillation over a Transonic Supercritical Profiles." AIAA Journal, Vol. 47, No. 9, 2009. Pages 1985-1994.

- **Validation of Structural Model for NASA CRM**

- Tap Test planned for comparison to normal mode solutions of FEM models
- Static Loads Tests will be conducted to compare deflection measurements (and maybe twist) to Linear Static FEM solutions

- **Users are encouraged to employ best practices for selected FEM codes**

- **Settings**

- Linear Eigenvalue Analysis (e.g. NASTRAN® SOL103)

- **Conditions**

- Rigid suspension at sting

- **Grid**

- MSC NASTRAN® solid 4-node tetrahedral finite-element structural model
- Model consists of $6.8 \cdot 10^6$ elements, $4.1 \cdot 10^6$ degrees-of-freedom
- Supplied by NASA Langley's Configuration Aerodynamics Branch
- Wind tunnel sting will be added as beam model



NASA CRM
Structural Model

Test Case 2a(E): W/B Deformation (cruise)



- CFD/FEM start from unloaded (wind-off) geometry/grid
- CRM Wing/Body
 - Reynolds number: 5M (LoQ)
 - Dynamic Pressure: $Q_{\infty} = 1384$ psf
 - Mach number: 0.85(M_{cruise})
 - CL = 0.5000 +/- 0.0001 (Angle of Attack ~ 2.75 deg)
 - Temperature: 120.0 F (579.67 R / 322.04 K)
 - Reference Information: <https://aiaa-dpw.larc.nasa.gov/Workshop7/DPW7-geom.html>
- Committee-supplied
 - NASA CRM geometry in jig/unloaded condition
 - Trip location – Wing: 10% chord upper/lower surface
 - Grid Family: https://dpw.larc.nasa.gov/DPW8/Static_Deformation/Test_Case_2
 - L1:~~T~~iny/L2:Coarse/L3:Medium/L4:Fine/L5:e~~X~~tra-fine/L6:Ultra-fine
 - NASA CRM finite-element model: https://dpw.larc.nasa.gov/DPW8/Static_Deformation/Test_Case_2/FEM_Models
- Comparison metrics
 - Forces / Moments
 - Sectional Twist / Deformation
 - Sectional C_p distribution
 - Residuals (Flow & Structural Solver)

Measured Span Stations

$\eta = (0.00, 0.4286, 0.5546, 0.6773, 0.7954, 0.9150)$

Test Case 2b(E): W/B Deformation (polar)



- CFD/FEM start from unloaded (wind-off) geometry/grid
- CRM Wing/Body
 - Reynolds number: 5M (LoQ)
 - Dynamic Pressure: $Q_{\infty} = 1384$ psf
 - Mach number: 0.85(M_{cruise})
 - Angles of attack: -1.50, 0.00, 1.50, **2.50**, 3.00, **3.50**, 4.00, 4.50
 - Temperature: 120.0 F (579.67 R / 322.04 K)
 - Reference Information: <https://aiaa-dpw.larc.nasa.gov/Workshop7/DPW7-geom.html>
- Committee-supplied
 - NASA CRM geometry in jig/unloaded condition
 - Trip location – Wing: 10% chord upper/lower surface
 - Grid Family: https://dpw.larc.nasa.gov/DPW8/Static_Deformation/Test_Case_2
 - L1:~~T~~iny/L2:Coarse/L3:Medium/L4:~~F~~ine/L5:e~~X~~tra-fine/L6:Ultra-fine
 - NASA CRM finite-element model: https://dpw.larc.nasa.gov/DPW8/Static_Deformation/Test_Case_2/FEM_Models
- Comparison metrics
 - Forces / Moments
 - Sectional Twist / Deformation
 - Sectional C_p distribution
 - Residuals (Flow & Structural Solver)

Measured Span Stations

$\eta = (0.00, 0.4286, 0.5546, 0.6773, 0.7954, 0.9150)$

Test Case 2a: Wing/Body Cruise



- Verification of steady CFD analysis
- CRM Wing/Body
 - Reynolds number: 5M (LoQ)
 - Dynamic Pressure: $Q_\infty = 1384$ psf
 - Mach number: 0.85(M_{cruise})
 - Angle of Attack = 2.50 deg
 - Temperature: 120.0 F (579.67 R / 322.04 K)
- Committee-supplied
 - NASA CRM geometry including deformed wing matching condition
 - Optional: Trip location – Wing: 10% chord upper/lower surface
 - Grid Family: https://dpw.larc.nasa.gov/DPW8/Scatter/Test_Case_2
 - L1:Tiny/L2:Coarse/L3:Medium/L4:Fine/L5:eXutra-fine/L6:Ultra-fine

- Reference Units

Sref (semi-span grid)	Cref	Semispan	Moment Center
297360.0 sq.in	275.8 in	1156.75 in	(1325.90, 0.00, 177.95)

- Comparison metrics

- Forces / Moments
- Sectional C_p distribution
- Residuals (Flow & Structural Solver)

Test Case 2b: Wing/Body Polar



- CFD/FEM start from unloaded (wind-off) geometry/grid
- CRM Wing/Body
 - Reynolds number: 5M (LoQ)
 - Dynamic Pressure: $Q_{\infty} = 1384$ psf
 - Mach number: 0.85(M_{cruise})
 - Angles of attack: -1.50, 2.50, 3.00, 3.50, 4.00, 4.50
 - Temperature: 120.0 F (579.67 R / 322.04 K)

- Committee-supplied
 - NASA CRM geometry in jig/unloaded condition
 - Optional: Trip location – Wing: 10% chord upper/lower surface
 - Grid Family: https://dpw.larc.nasa.gov/DPW8/Scatter/Test_Case_2
 - L1:Tiny/L2:Coarse/L3:Medium/L4:Fine/L5:eXtra-fine/L6:Ultra-fine

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- Comparison metrics

- Forces / Moments
- Sectional C_p distribution
- Residuals (Flow & Structural Solver)
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