

DPW-8 & AePW-4 Workshop Update



Fall Workshop-Wide Tagup
November 8, 2024



<https://aiaa-dpw.larc.nasa.gov>

<https://nescacademy-d.larc.nasa.gov/workshops/AePW4/public>

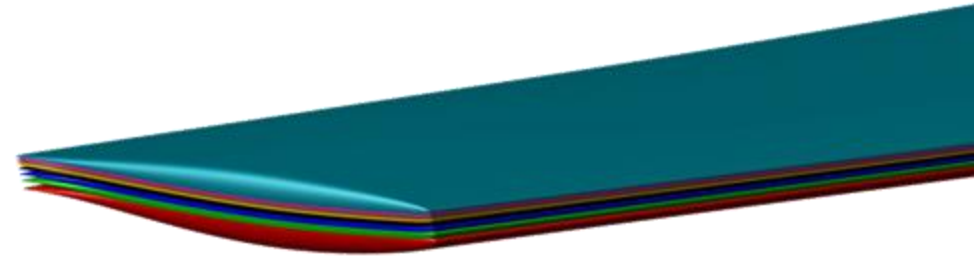
- **Welcome**
- **Background & Reminder**
- **Schedule**
- **Working Groups Update**
 - DPW-Centric Working Groups
 - AePW-Centric Working Groups
 - Hybrid Working Groups
- **Open Discussion**

- Continue expanding the envelope
- Accurate aerodynamic prediction provides significant value throughout aircraft product life-cycle; design, certification, in-service support
- Drag prediction for a known geometry in steady (mostly attached) flow is generally achievable, but questions remain:
 - Confidence in the geometry?
Jig shape is defined but deformed loaded shape is required for accurate predictions
 - Confidence in the evolution from steady to unsteady flow?
When does unsteadiness begin and steady assumptions are no longer valid?
 - Source of the remaining scatter?
Function of grid type, solver scheme, turbulence model
 - Unknown uncertainty from comparing free-air CFD to wind tunnel test data
Some existing global corrections to upflow/forces/moments, tare & interference not quantified
No corrections for spanwise variations to sectional pressures

- **Build on past DPWs to improve confidence in aircraft performance prediction**
- **Mature the foundations required for accurate prediction**
 - To accurately predict drag, we need confidence in numerical models
 - Building upon good models, we need accurate definition of geometry under load
 - Unsteady analysis requires confidence in unsteady schemes
- **Determination of accuracy requires comparison to “truth”**
 - Experimental data are one form of “truth” but can have significant differences that must be understood to make practical comparisons to CFD
- **Leverage comprehensive experimental data sets for high-quality comparisons**
- **Increase student participation**

- **An open and impartial forum to assess and evaluate the current state-of-the-art and state-of-the-practice in computational aeroelastic modeling**
 - How effective are current solvers at predicting aeroelastic physics critical to aircraft analysis and design?
 - Can we establish best-practices for using aeroelastic solvers?
 - How can we understand the reasons for why our solvers may fail?
 - Can we specify requirements on future validation experiments?
 - What computational and experimental areas of research need further development?
- **Historically (AePW-1 and -2) was solely focused on transonic problems: unsteady CFD-based aerodynamics and aeroelasticity**
- **AePW-3 expanded to multiple WGs looking at a variety of flow regimes**
- **AePW-4 will continue in this same direction**

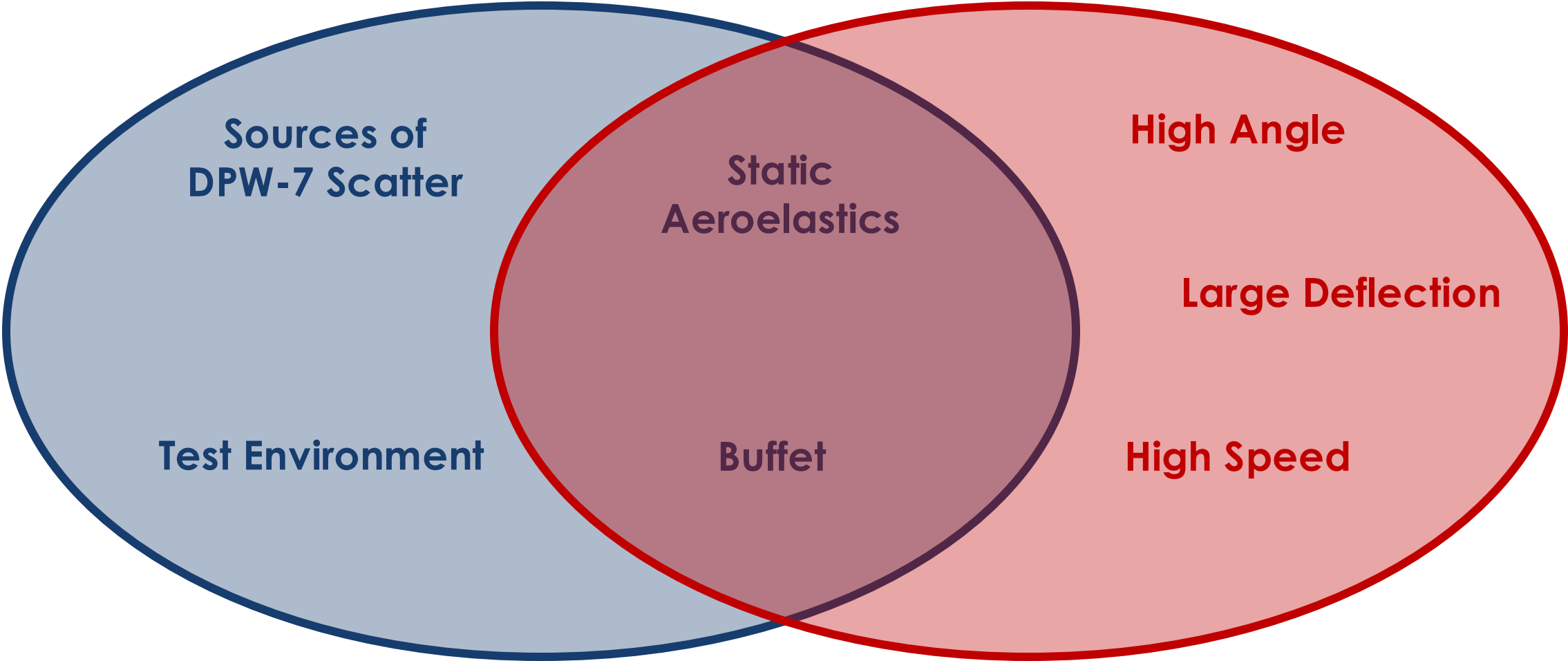
- **Next generation of computational goals is highly multidisciplinary**
- **Enable technical advances to cutting edge in industry**
 - DPW has expertise in transonic CFD
 - AePW has expertise in computational aeroelasticity at many flight regimes
- **DPW-8 and AePW-4**
 - More than simply co-located workshops
 - Multiple working groups
 - Workshops overlap with a central goal and then specialize in other tasks specific to each community
- **Goals**
 - Benchmark methods performance between multiple codes and schemes
 - Establish state of the art for static and dynamic FSI; identify opportunities for improvement



Experimentally-determined
lofts from DPW-VII

DPW

AePW



Sources of DPW-7 Scatter

Test Environment

Static Aeroelastics

Buffet

High Angle

Large Deflection

High Speed

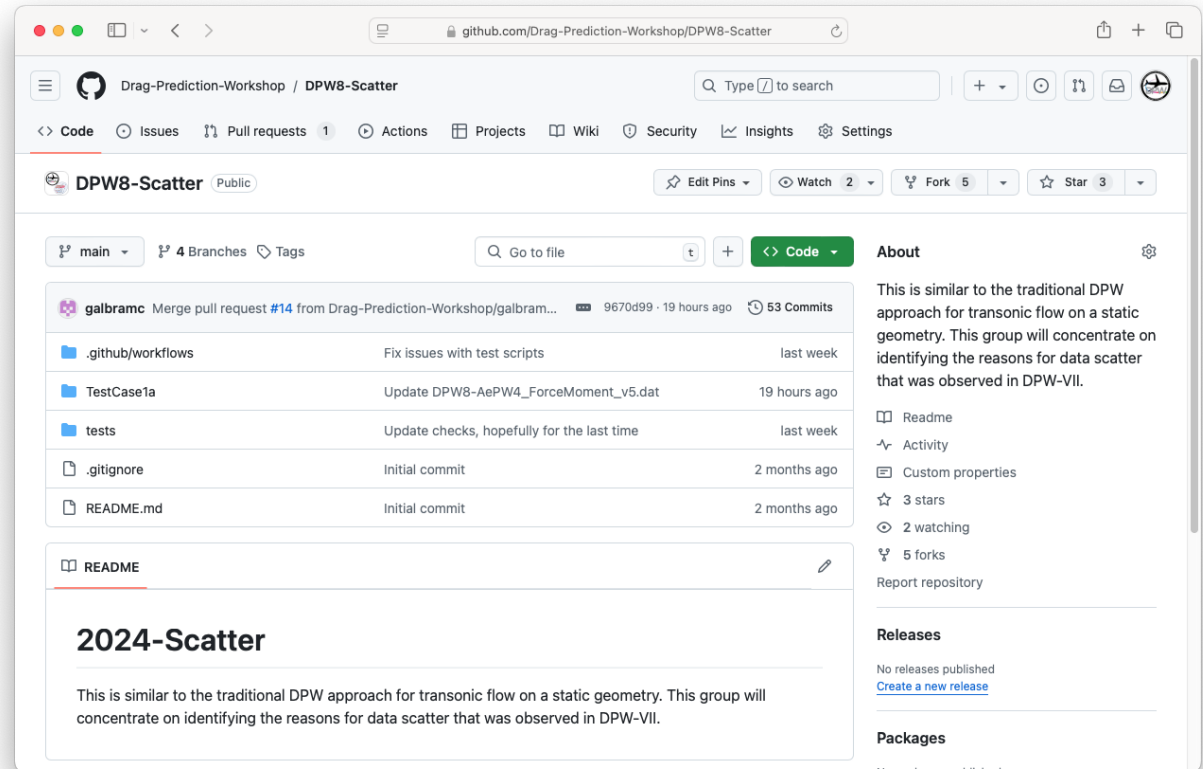
A Special Note For Students

- **Students (undergrad and grads) are strongly encouraged to participate**
- **Workshop seeks to develop the student**
- **Minimize barrier to entry to submit data**
 - Compute resources for students may be limited
 - All test cases do not need to be completed
 - Minimum for participation is one polar at one grid density
- **Compute time and postprocessing licenses are available, if needed**
- **Contact dpwaiaa@gmail.com for more information**

- **May 2024**
 - Working groups begin ✓
 - First test cases defined ✓
- **July 2024**
 - AVIATION in-person meeting ✓
- **Fall 2024**
 - Isolated data due ✓
 - Additional test cases defined 💡
- **January 2025**
 - Mini Workshop 1 (SciTech), hybrid
- **June 2025**
 - AVIATION in-person meeting
- **Summer 2025**
 - Additional test case data may be due
- **Fall 2025**
 - Mini Workshop 2 (possibly), virtual
- **January 2026**
 - SciTech in-person meeting
- **March 2026**
 - Delivery of final data set (as needed)
- **June 2026**
 - Two-day workshop at AVIATION
- **January 2027**
 - SciTech Special Sessions, Orlando, FL

- **Data Submission Process**
- **DPW Centric**
 - Source of Scatter Working Group
 - Test Environment Working Group
- **AePW Centric**
 - High-Angle Working Group
 - Large Deformation Working Group
 - High-Speed Working Group
- **Hybrid**
 - Static Deformation Working Group
 - Buffet Working Group

- **One stop shop for all DPW-centric and hybrid groups data**
 - Improves version control
 - Ensures all committee members are looking at the most recent data
- **Public and outward-facing**
- **A top-level README.md identifies institutions, individuals, and codes**



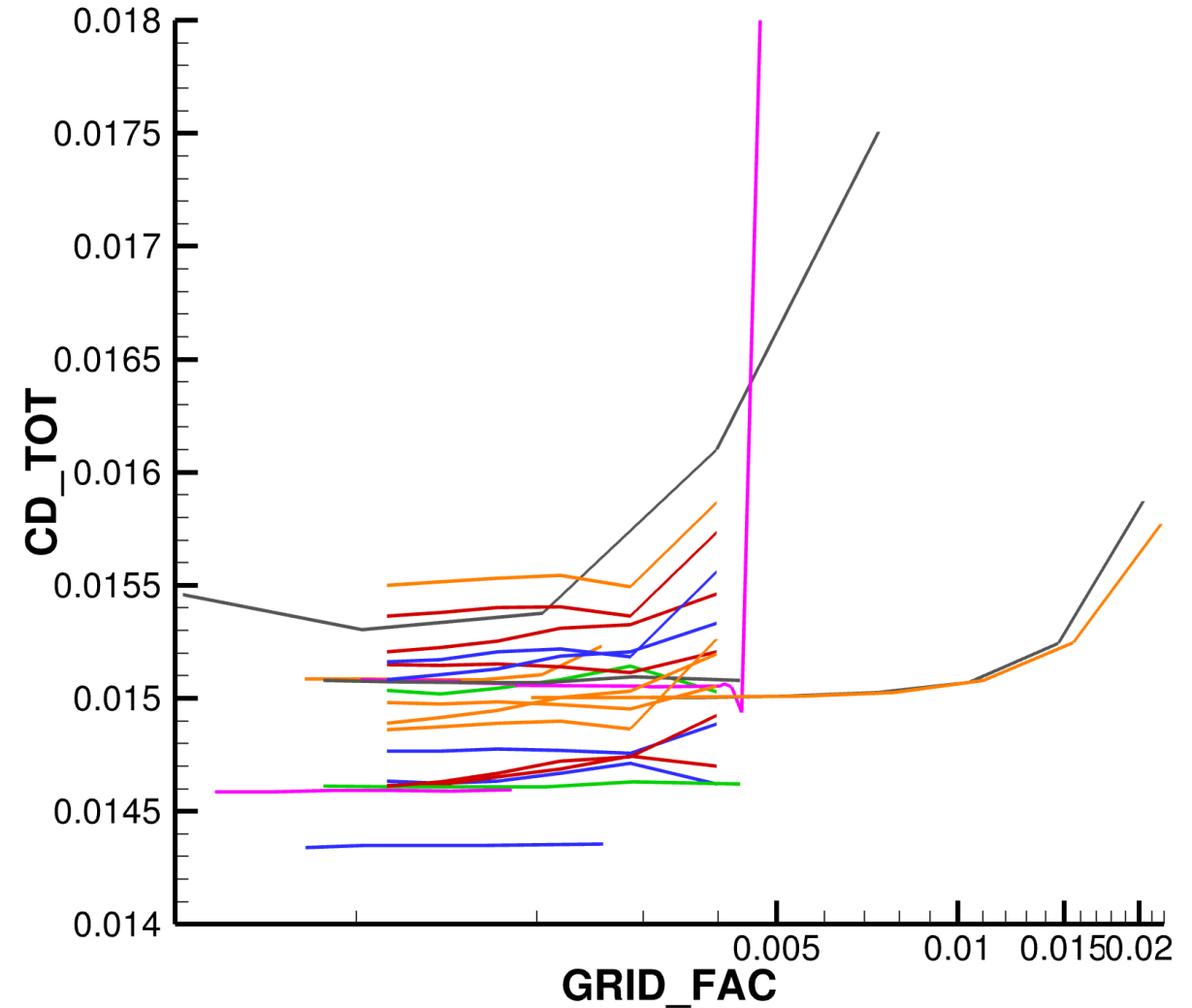
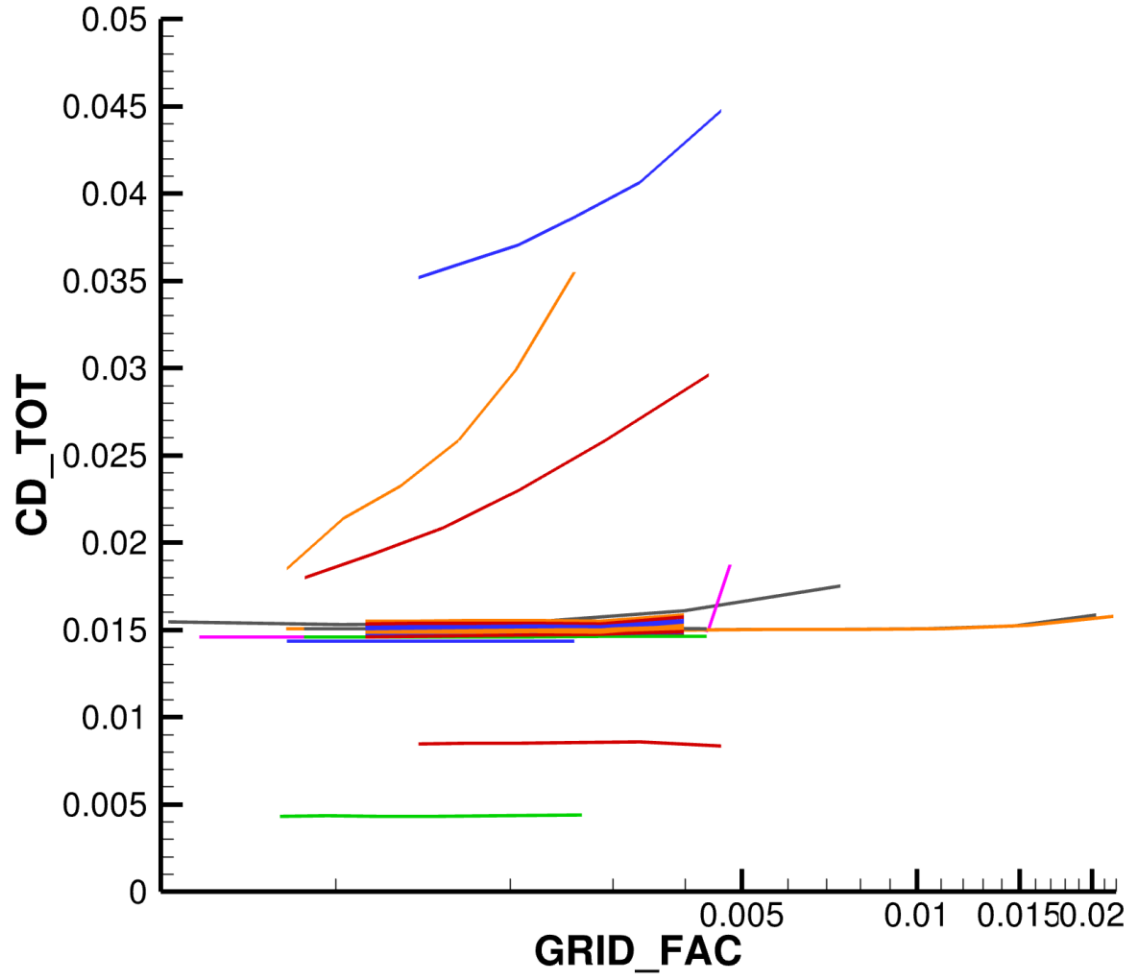
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- **Three test cases defined to varying degrees**
 - Test Case 1: ONERA OAT15A (now)
 - Test Case 2: Joukowski Airfoil
 - Test Case 3: CRM Wing
- **Sustained meeting cadence and structure**
 - Approx 20 people on distribution list
 - Average 15 attendees in each meeting
 - Meeting Tuesdays 10am ET on 2nd and 4th week of the month
 - Variety of committee-supplied and custom grids

Sources of Scatter – All Workshop Submissions

- We have Scatter!

ONERA OAT15A Airfoil: $\alpha = 1.5^\circ$



Sources of Scatter – Scatter Participants

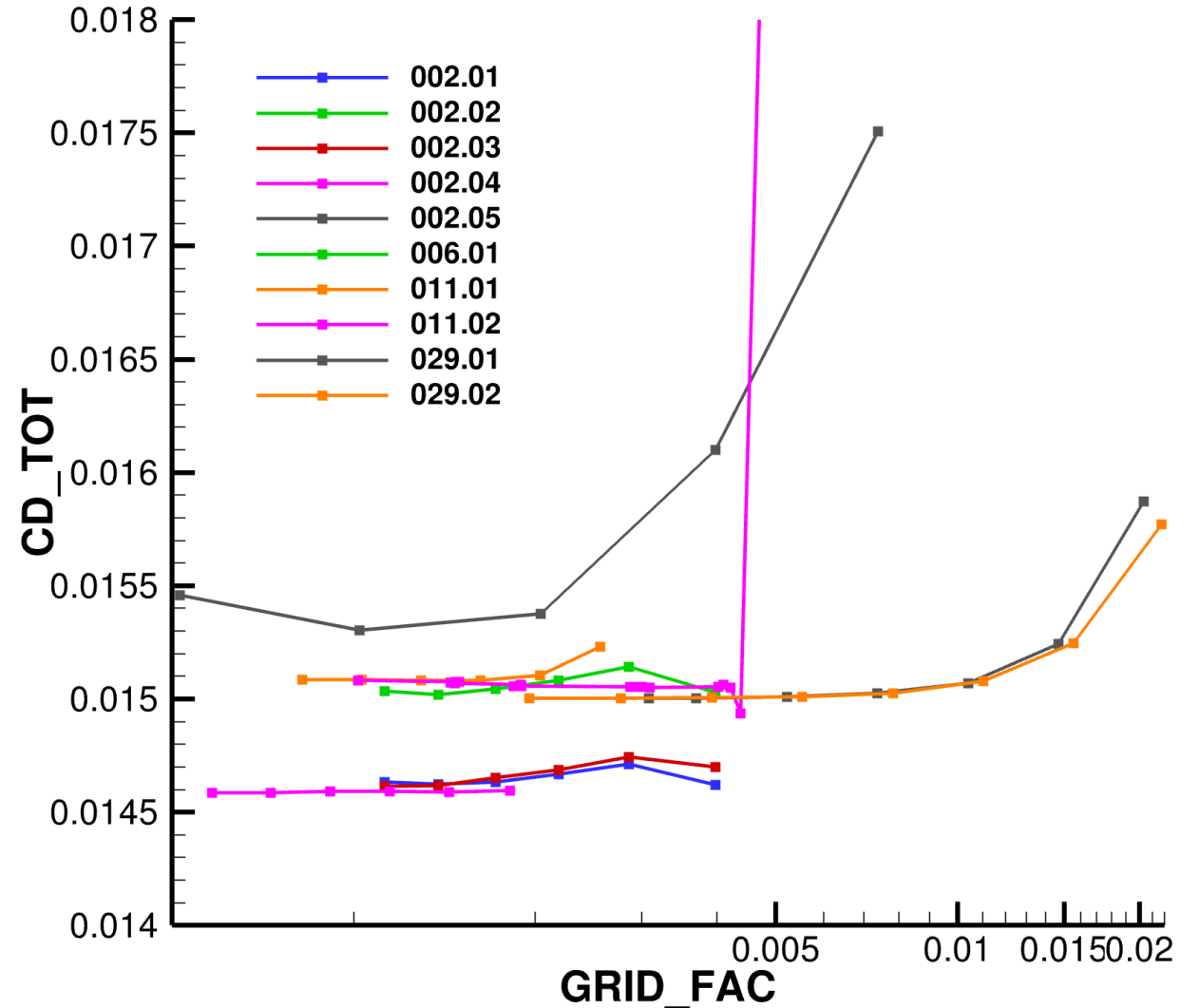
- **Scatter participants**

- 4 group submissions
- 10 data sets

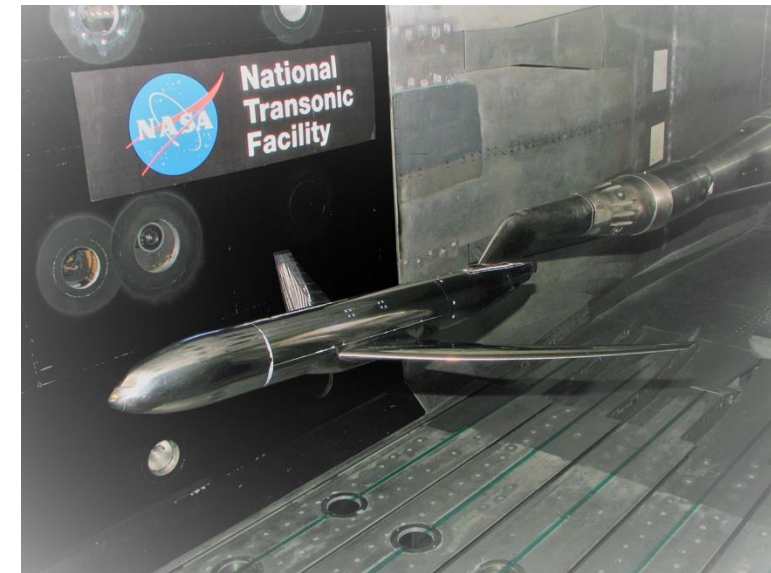
- **Need more participation**

- Lots more scatter from full workshop

ONERA OAT15A Airfoil: $\alpha = 1.5^\circ$



- **Working Group High Level Goal:**
 - Increase understanding and quantify expectations for comparisons between free-air CFD and measured Wind Tunnel “truth”
 - Force/Moment balance and pressure tap measurements
- **Planning is on-going**
 - Phase 0: ONERA OAT15A Airfoil
 - Phase 1: Tare & Interference from Model Mounting System
 - i. NASA CRM
 - ii. NASA CRM + Upper Swept Strut & Sting
 - iii. NASA CRM + Upper Swept Strut & Sting + Arc Sector
 - Phase 2: Wind Tunnel Walls
 - i. NASA CRM
 - ii. NASA CRM + Wind Tunnel Walls
 - iii. NASA CRM + Wind Tunnel Walls + Upper Swept Strut & Sting + Arc Sector



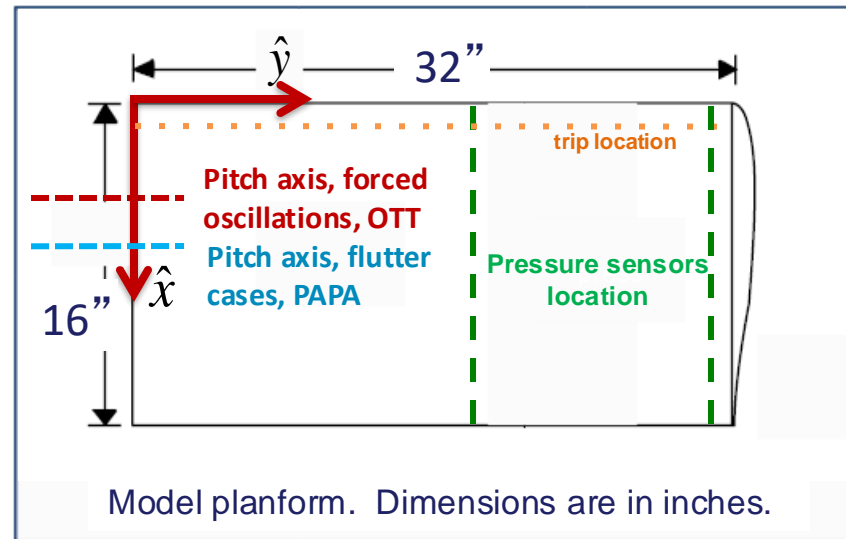
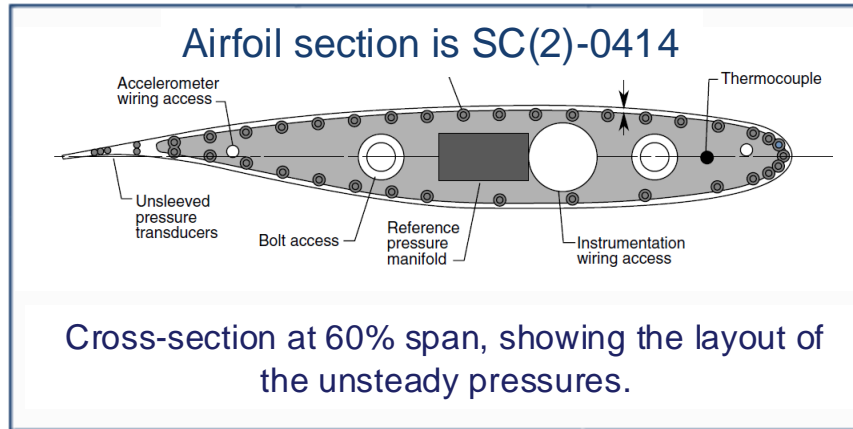
- **Potential Leader Identified**
 - If confirmed, WG meetings will commence in the next few weeks
- **Geometry Status**
 - NASA CRM geometry is available
 - Upper Swept Strut and Sting Geometry verified as accurate representation
 - NTF Tunnel Geometry, including arc-sector, is available
- **Grid Status**
 - TBD
- **Comparison Data**
 - TBD
- **Meeting Schedule**
 - TBD

- **DPW Centric**
 - Source of Scatter Working Group
 - Buffet Working Group
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- **Led by Pawel Chwalowski, NASA Langley**
 - We meet the 2nd Thursday of every month at 10 ET
- **Focus on transonic aeroelastic flutter**
 - This WG dates back to AePW-1 (2012), AePW-2 (2019), and AePW-3 (2023)
 - AePW-3 had also considered transonic buffet
- **Utilize the Benchmark Supercritical Wing (BSCW)**
 - Tested in the NASA LaRC Transonic Dynamics Tunnel (TDT) in the early 1990's, as part of the Benchmark Models Program
 - A rigid rectangular wing attached to a pitch and plunge apparatus (PAPA)
 - Experimental flutter points at a range of Mach and AoA's
 - Finite element model available, as well as a family of unstructured meshes
 - Scheduled to be tested again in TDT in summer of 2025 (uPSP, PIV, sweep of Mach and AoA's)

High Angle – Configuration / Data

BSCW inside Transonic Dynamics Tunnel test section



EXPERIMENTAL UNSTEADY PRESSURES AT FLUTTER ON THE SUPERCRITICAL WING BENCHMARK MODEL

Bryan E. Dansberry, Michael H. Durham*, Robert M. Bennett**, José A. Rivera*, Walter A. Silva*, and Carol D. Wieseman*; Structural Dynamics Division, NASA Langley Research Center, Hampton, VA 23681-0001 and David L. Turnock* Lockheed Engineering and Sciences Corporation

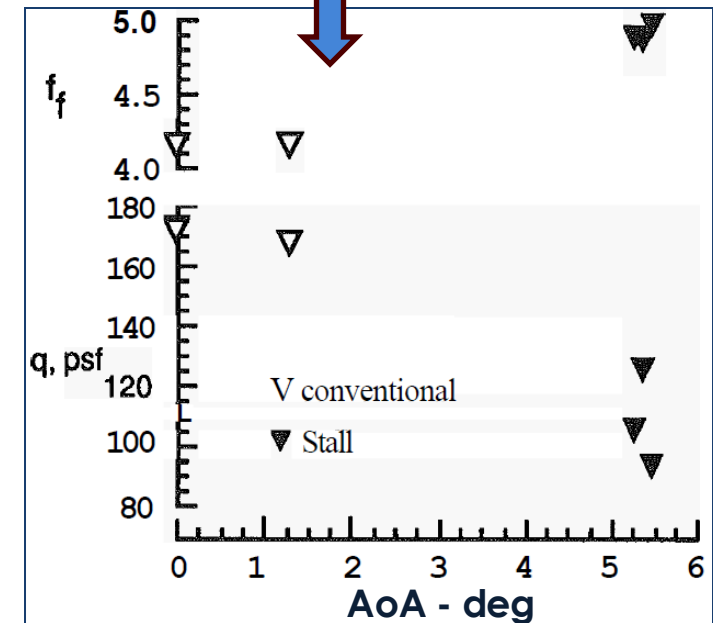
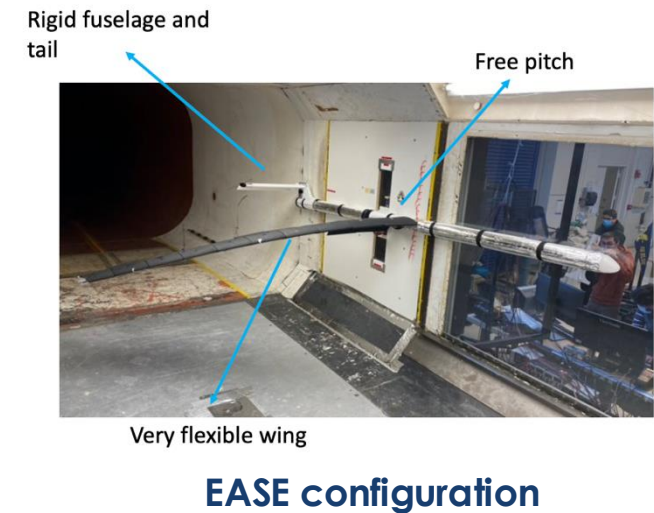
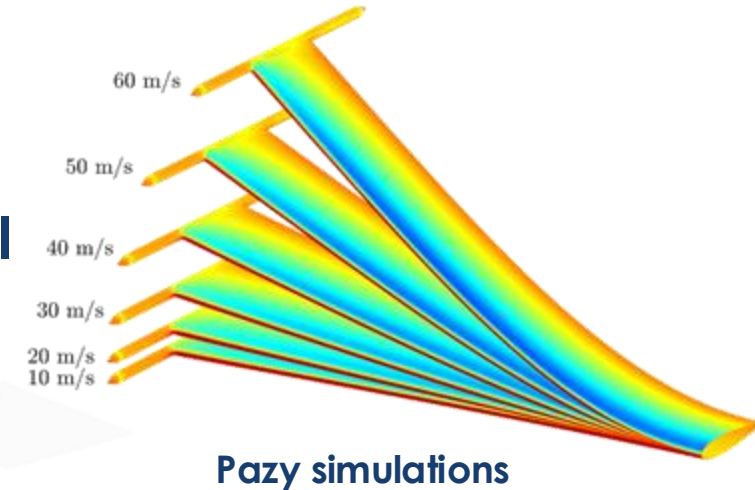


Figure 9. Stall flutter boundary in R-12 at $M = 0.80$.

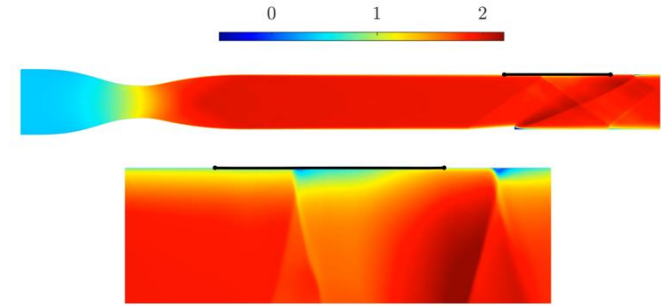
- AePW-1:
 - Steady-rigid and forced-oscillation cases at Mach 0.85, AoA = 5° ✓
- AePW-2:
 - Forced-oscillation case at Mach 0.70, AoA = 3° ✓
 - Flutter prediction at Mach 0.74, AoA = 0° ✓
 - Unsteady-rigid, forced-oscillation, and flutter cases at Mach 0.85, 5° ✓ ✓ ✓
- AePW-3:
 - Flutter prediction at Mach 0.80, AoA = 5° ✓
 - Shock-buffet case at Mach 0.80, AoA = 5° ✓
- **AePW-4: Mandatory case**
 - Flutter prediction at Mach 0.80 and angle-of-attack sweep: 0° – 6°
- **AePW-4: Optional case**
 - Flutter prediction at Mach 0.74, 0.76, 0.78 and angle-of-attack 3°

✓ Poor flutter prediction
✓ Good flutter prediction
✓ Mixed flutter prediction

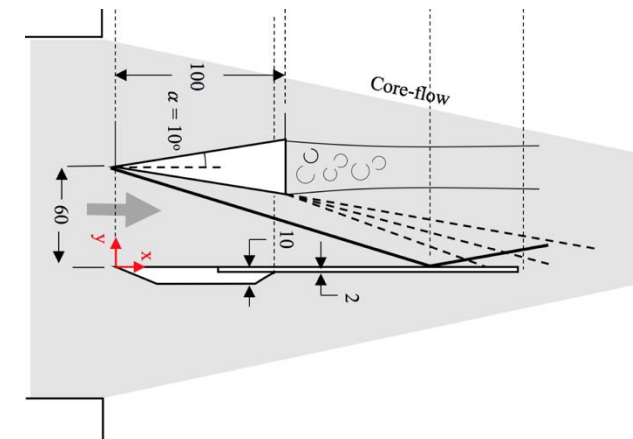
- **Led by Rafael Palacios, Imperial College**
 - We meet the 3rd Thursday of every month at 11 ET
- **Focus on low-speed aeroelastic problems with structural nonlinearities**
 - Slender, high aspect ratio wings
 - The previous iteration of this WG (AePW-3) had considered Technion's Pazy Wing
 - Increased AoA \rightarrow change in structural stiffness \rightarrow shift in flutter boundaries
- **The current iteration of this group is still deciding where to go next**
 - Could continue with variations of the Pazy configuration
 - Or could consider Michigan's EASE configuration: high aspect ratio wing, with control surfaces, attached to a PAPA



- **Led by Kirk Brouwer, US AFRL**
 - We meet the 4th Thursday of every-other-month at 5pm ET
 - And the alternating months at 8am ET
- **The current iteration of this group will continue with the same 2 test cases considered in AePW-3**
 - AFRL's RC19 case: Mach-2 flow over a flexible panel
 - UNSW's HyMax case: wedge-based shock impingement on a cantilevered plate at Mach-6
- **We've had work presented by Duke, MIT, NASA, UNSW, DLR**
- **The aeroelastic physics of these cases are very complex, expensive, and hard-to-predict**
 - We are working to develop single-discipline unit cases
 - These will provide a collaborative opportunity with the AIAA High Speed FSI DG



RC19 simulations



HyMax configuration

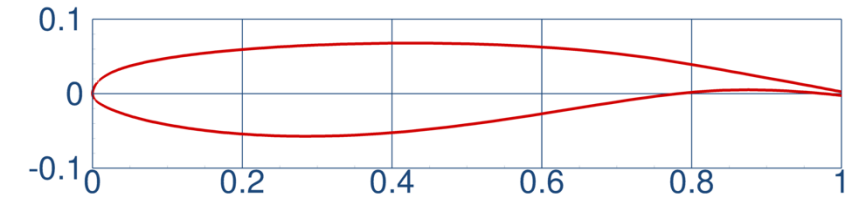
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- **Three test cases defined to varying degrees**
 - Test Case 1a: ONERA OAT15A (now)
 - Test Case 1b: NASA CRM FEM Validation
 - Test Case 2: CRM Wing/Body
 - Test Case 3: CRM Wing/Body/Nacelle/Pylon
- **Sustained meeting cadence and structure**
 - More than 70 people on distribution list
 - Average 20-25 attendees in each meeting
 - Meeting Fridays 10am ET on 2nd week of the month
 - Variety of committee-supplied and custom grids

Static Deformation Current Status

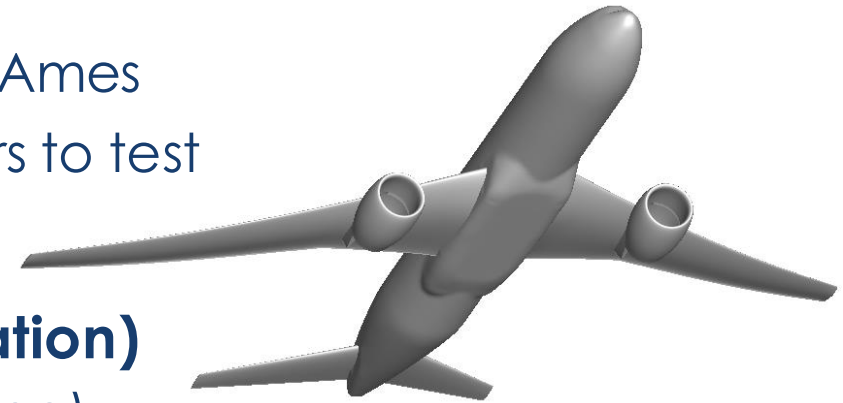
- **Test Case 1a (ONERA OAT15A Airfoil)**
 - RANS, essentially complete
 - Data submitted to GitHub successfully

- **Goal is to inform later analysis and not necessarily exhaustively study the solutions**

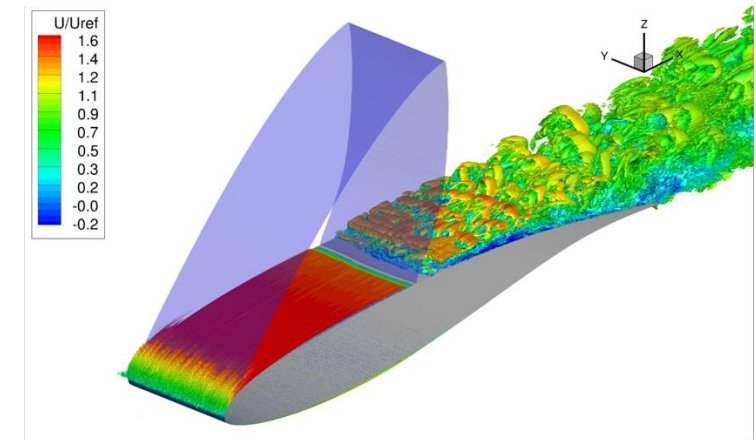
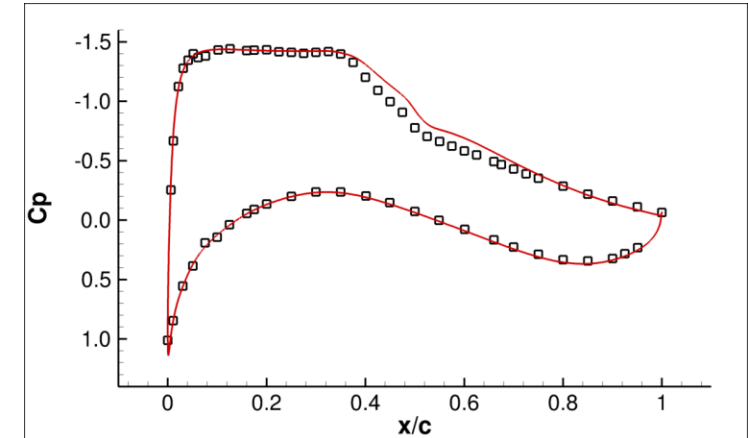


ONERA OAT15A Transonic Airfoil

- **Test Case 1b (NASA CRM FEM Validation)**
 - Validation data will be collected in the future
 - NASA CRM Model not available until December to conduct static load and tap tests
- **Test Case 2 (CRM Wing/Body Deformation)**
 - NASA CRM geometry (initialize from unloaded wing shape)
 - NASA CRM FEM available
 - Maintain consistency with published grid standards
 - Grids being prepared by Cadence, Helden, and NASA Ames
 - First look at grids later this month → looking for volunteers to test
 - Hope to finalize details by mid December
- **Test Case 3 (CRM Wing/Body/Nacelle/Pylon Deformation)**
 - NASA CRM geometry (initialize from unloaded wing shape)



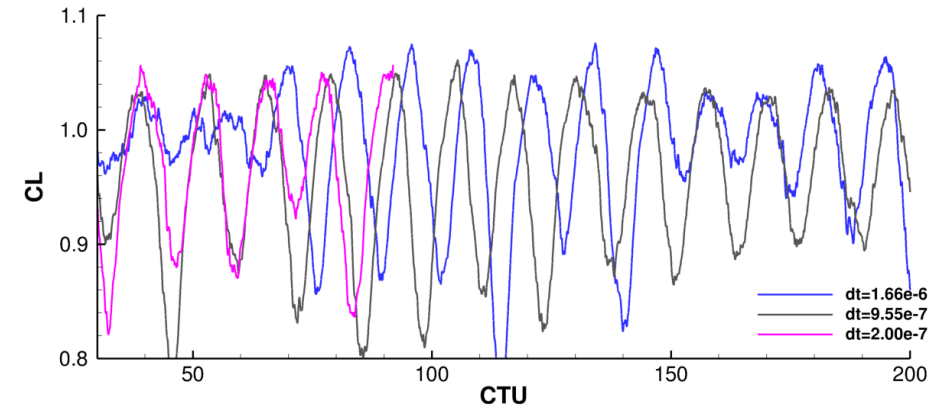
- **Three test cases defined to varying degrees**
 - Test Case 1: ONERA OAT15A (now)
 - Test Case 2: CRM Fixed-Geometry and Unsteady CFD (roughly Spring and Summer 2024)
 - Test Case 3: CRM Unsteady Fluid Structure Interaction (roughly Winter 2024 and Spring 2025)
- **Sustained meeting cadence and structure**
 - More than 100 people on distribution list
 - Average 50 attendees in each meeting
 - Includes monthly working group meetings and monthly subgroups by scheme (URANS, hybrid RANS+LES, WMLES & Beyond)
 - Variety of committee-supplied and custom grids
 - Starting to diverge from other working groups



Credit (both): Jeff Housman, NASA Ames

Buffet Current Status

- **Test Case 1a**
 - RANS, essentially complete
 - Data submitted to GitHub successfully
- **Test Case 1b (Buffet Working Group Supplement)**
 - Unsteady simulations, in final preparation
 - Standardized signal postprocessing methods
- **Goal is to inform later analysis and not necessarily exhaustively study the solutions (to be done by the Scatter Working Group)**



Credit: Jeff Housman, NASA Ames

- **Test Case 1 (ONERA OAT15A)**
 - Hopefully complete by end of November
 - Later data submissions may happen
- **Test Case 2 (CRM Wing/Body/Tail, Unsteady CFD, Static Wing)**
 - Maintain consistency with published grid standards
 - Experimentally-measured JAXA geometry
 - Grids being prepared by Cadence, Helden, and Ames – thanks!
 - First look at grids later this month → looking for volunteers to test
 - Plan to finalize details by mid December (so you can run over winter break)
- **Test Case 3 (CRM Wing/Body/Tail, Unsteady CFD, Dynamic Wing)**
 - CRM wing/body/tail
 - Will be very challenging
 - In the future

- **Working Groups should identify and document the “Key Questions” that will attempt to be answered**
 - High Lift PW leaders found this helps to provide focus and allows evaluation of progress made by the end of the workshop
- **Example “Key Questions” for the Static Deformation Group**
 - How accurately can transonic wing deformation be calculated?
 - What is the uncertainty in configuration force/moments due to aeroelastic deformation uncertainty?
 - What are the most efficient/accurate methods for coupling the aero/structural computations?
 - What are the computational time/accuracy savings between using a full fidelity vs reduced beam structural model?
 - Do modal solutions compare well to direct fluid-structure mapping solutions?
 - Does a full vs symmetry plane solution result in different solutions?
 - How much accuracy is lost by using a “lower fidelity” aerodynamic simulation (e.g., panel methods or vortex lattice)?

Workshop Structure

- **Two full-day workshop at AVIATION '26**
- **First day**
 - Community centric in two separate rooms
 - Technical lessons learned
 - Future plans
- **Second day**
 - Everyone together
 - Hybrid groups
 - Workshop lessons learned
 - Future plans

- **DPW site contains field-specific and shared data**
 - Working Group pages for four DPW-focused groups
 - Geometry
 - Grids
 - Postprocessing data file templates
 - Experimental results
- **AePW site is going live soon**
- **<https://aiaa-dpw.larc.nasa.gov>**
- **<https://nescacademy-d.larc.nasa.gov/workshops/AePW4/public>**

Open Discussion

