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

Agenda

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

DPW-8 Motivation & Background

- **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    When does unsteadiness begin and steady assumptions are no longer valid?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

DPW-8 Goals

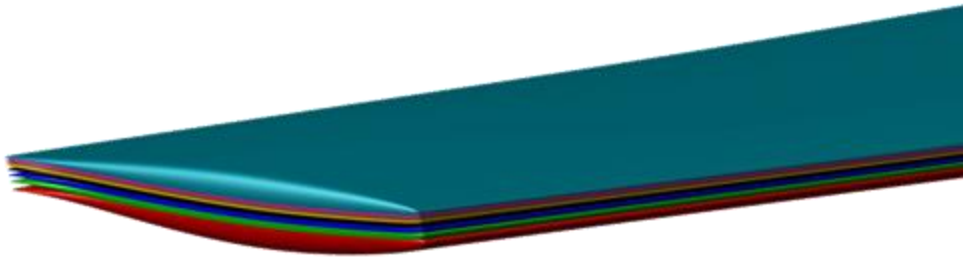
- **Build on past DPWs to improve confidence in aircraft performance prediction**
- **Mature the foundations required for accurate prediction**
  - To accurately predict drag, we need confidence in numerical models
  - Building upon good models, we need accurate definition of geometry under load
  - 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**

AePW-4 Motivation and Background

- **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**

DPW-8 and AePW-4 Co-Hosted Workshop

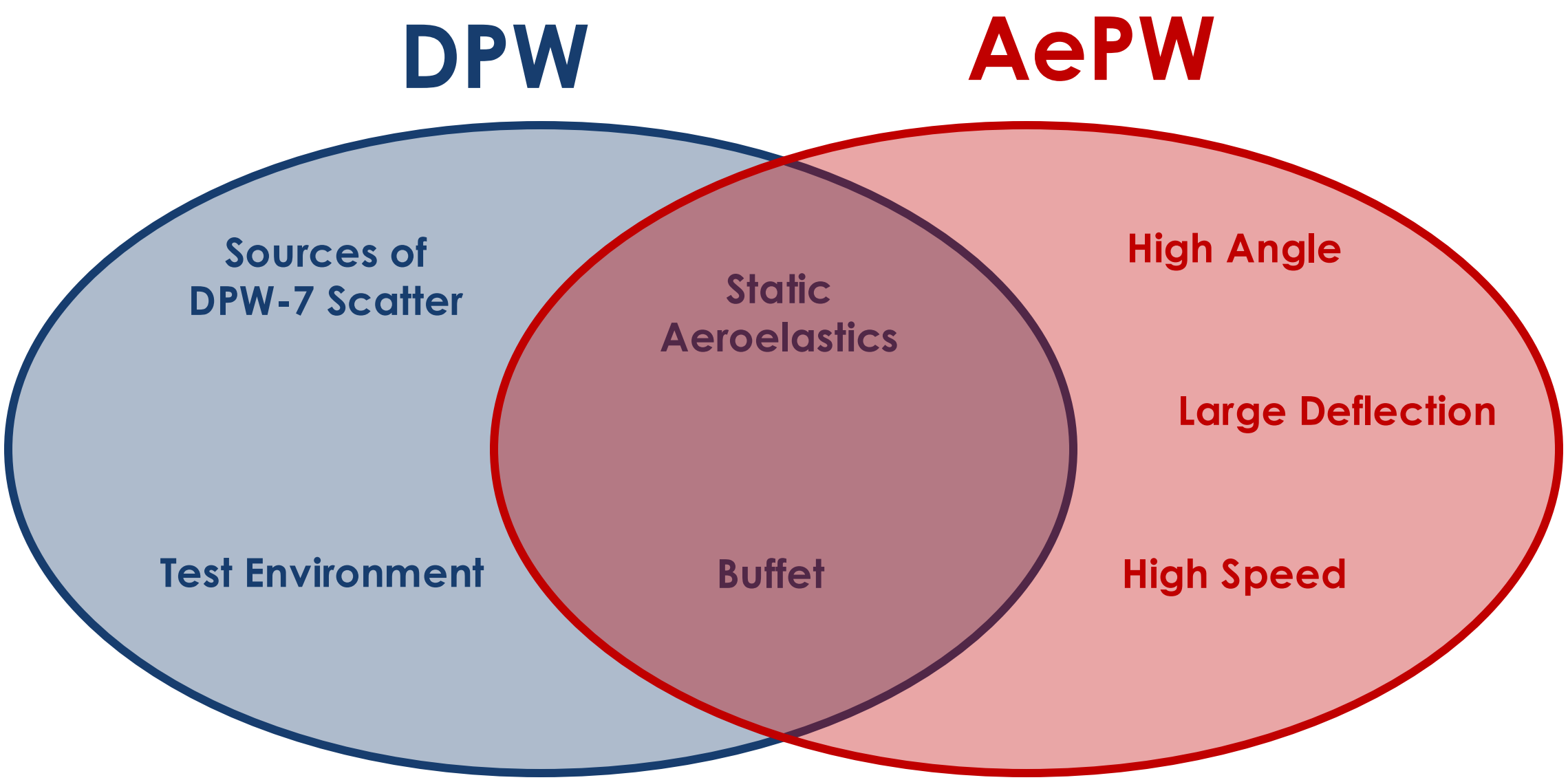
- **Next generation of computational goals is highly multidisciplinary**
- **Enable technical advances to cutting edge in industry**
  - DPW has expertise in transonic CFD
  - AePW has expertise in computational aeroelasticity at many flight regimes



Experimentally-determined lofts from DPW-VII

- **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

Working Groups Layout



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**

Nominal Schedule

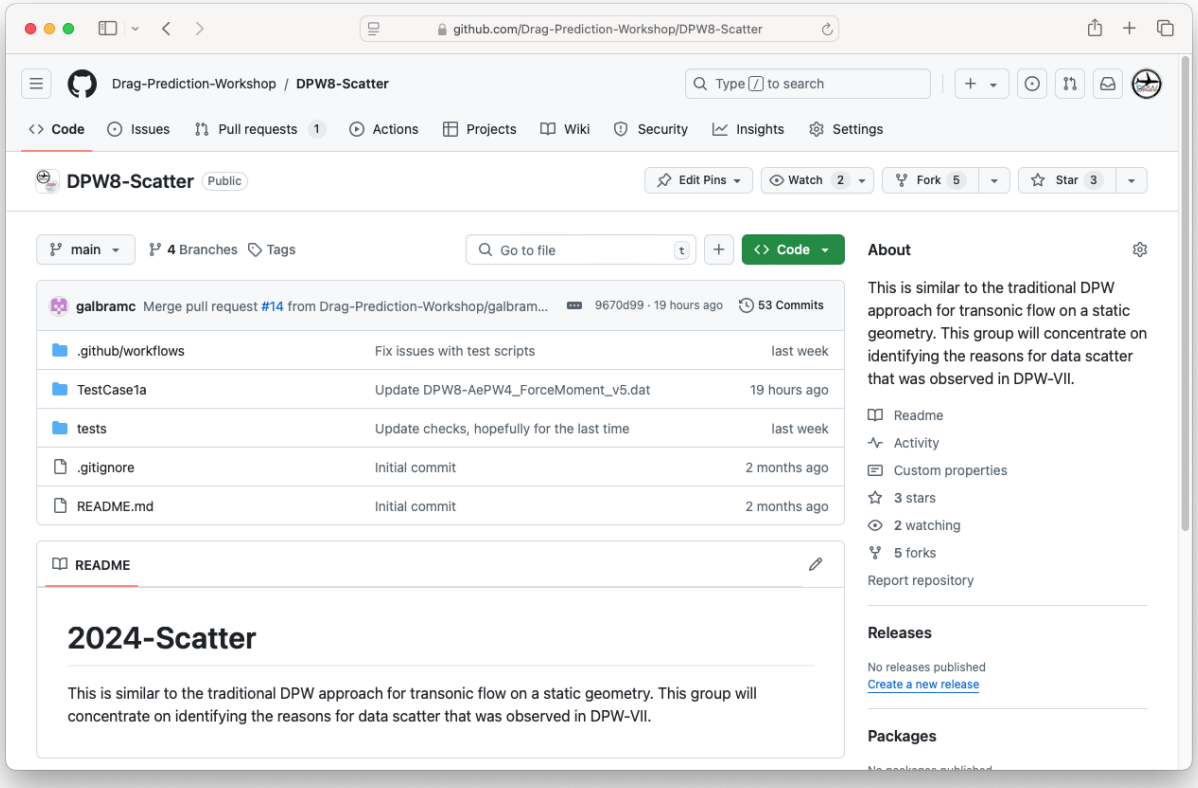
- **May 2024**
  - Working groups begin ✔
  - First test cases defined ✔
- **July 2024**
  - AVIATION in-person meeting ✔
- **Fall 2024**
  - Isolated data due ✔
  - Additional test cases defined 💡
- **January 2025**
  - Mini Workshop 1 (SciTech), hybrid
- **June 2025**
  - AVIATION in-person meeting
- **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

Working Groups Update

- **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

GitHub Repository

- **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**



Working Groups Update

- **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

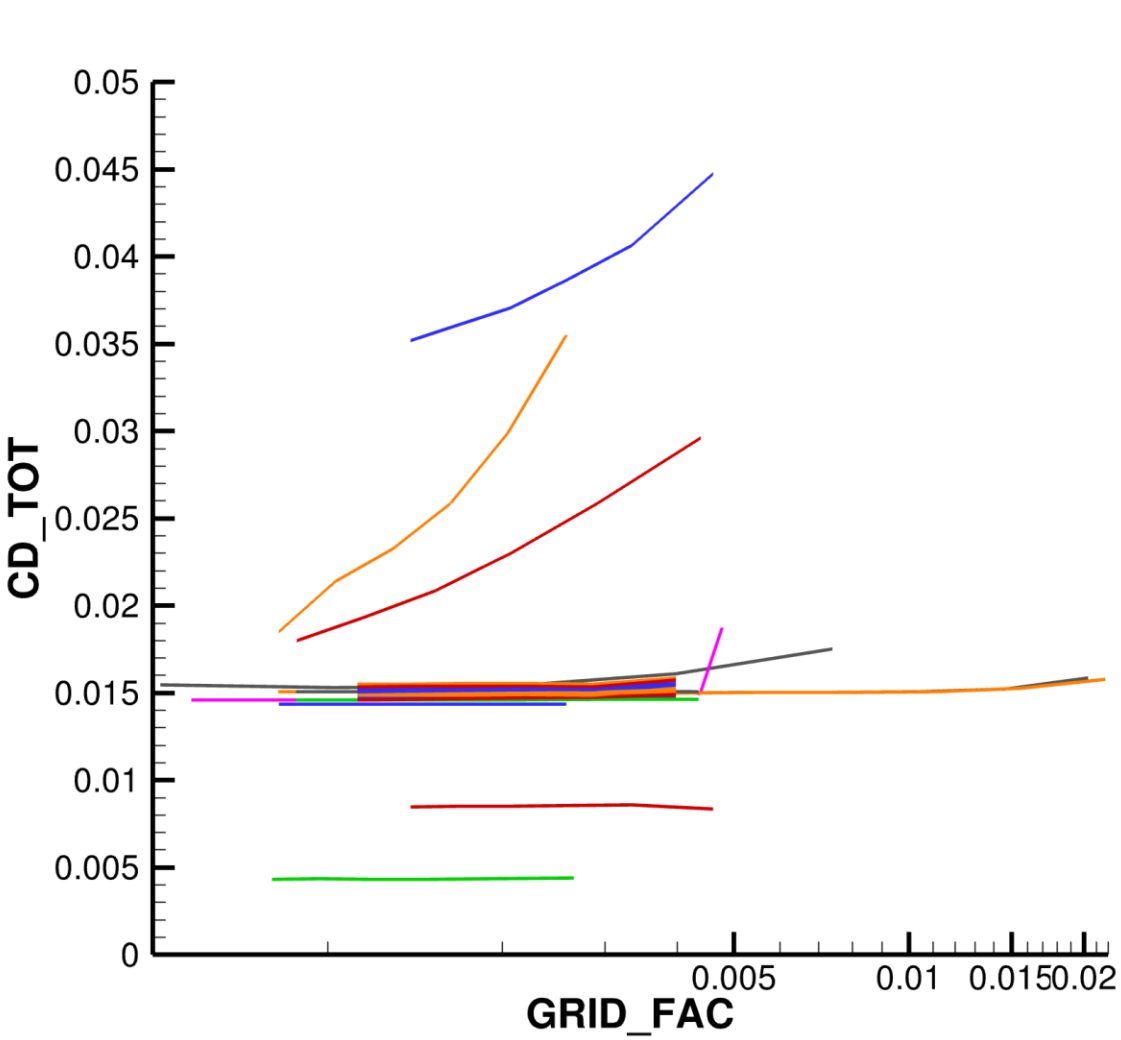
Sources of Scatter – Overview

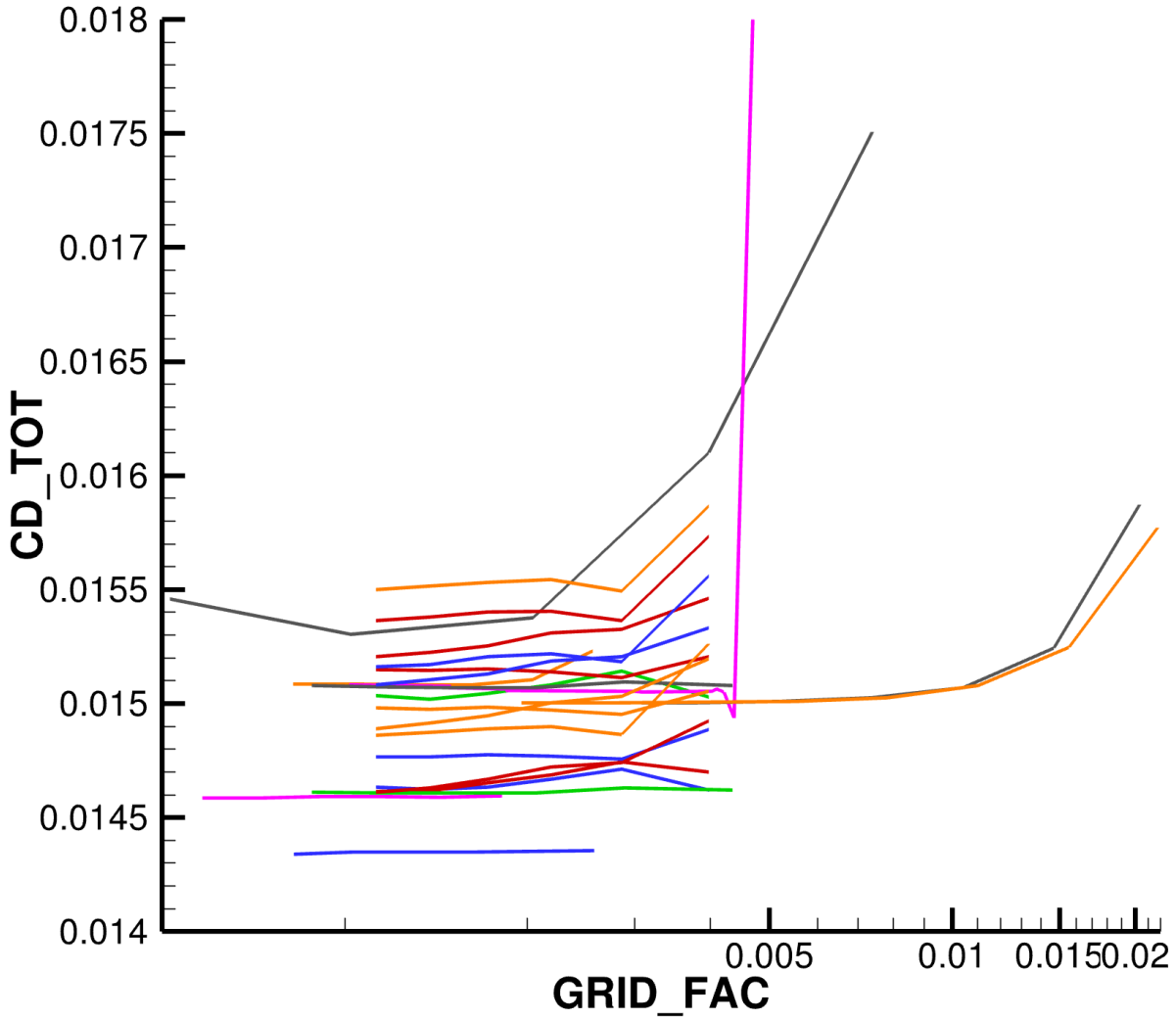
- **Three test cases defined to varying degrees**
  - Test Case 1: ONERA OAT15A (now)
  - Test Case 2: Joukowksi Airfoil
  - Test Case 3: CRM Wing
- **Sustained meeting cadence and structure**
  - Approx 20 people on distribution list
  - Average 15 attendees in each meeting
  - Meeting Tuesdays 10am 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: $\alpha = 1.5°$

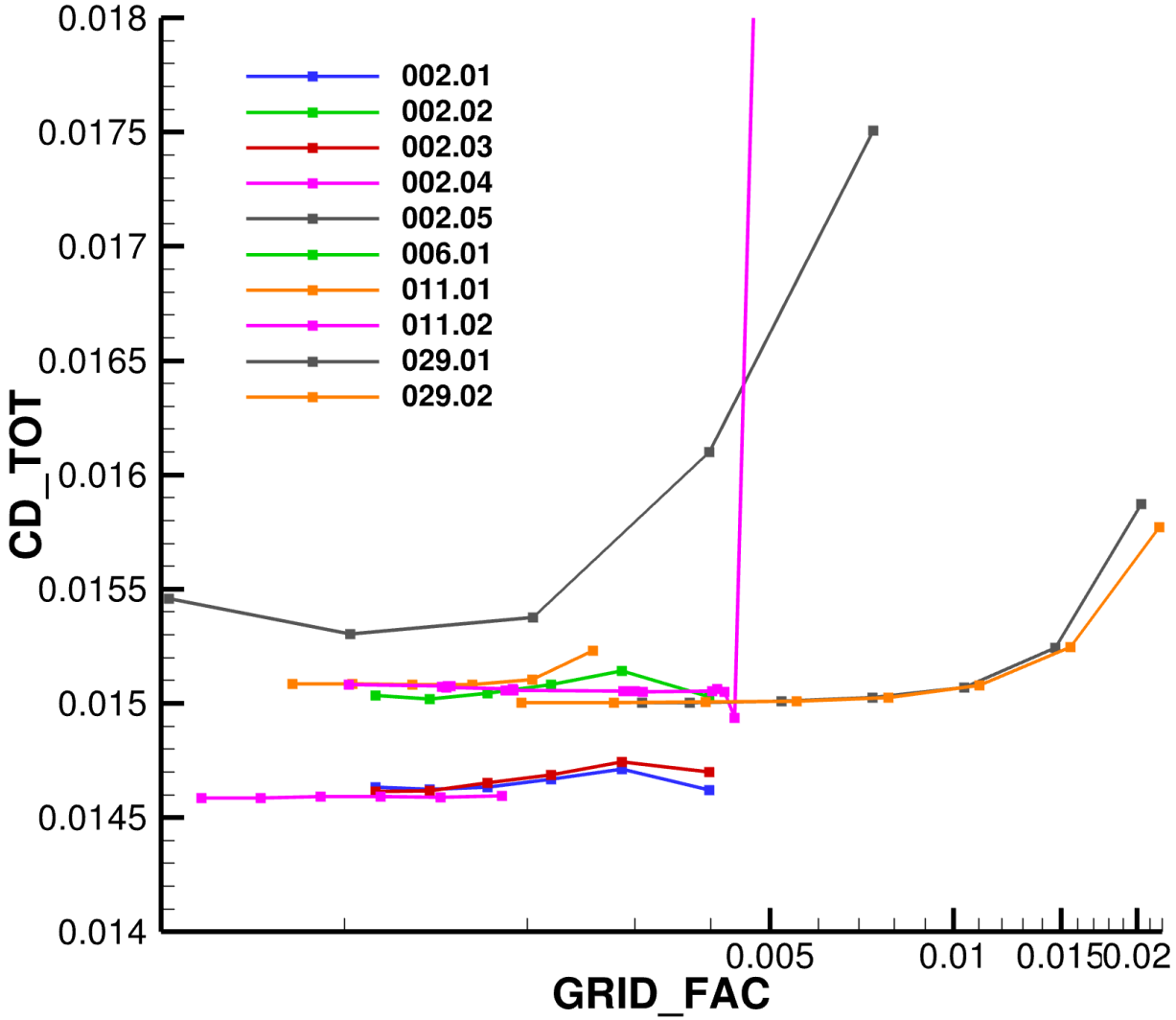




Sources of Scatter – Scatter Participants

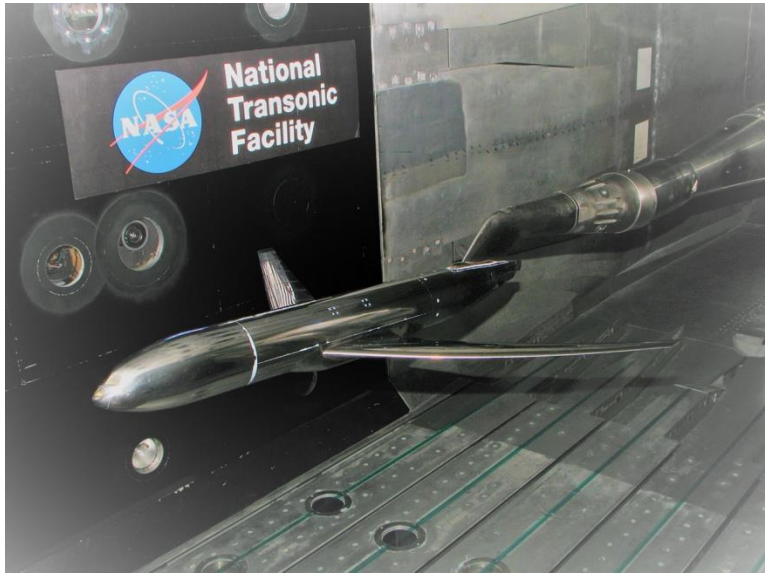
- **Scatter participants**
  - 4 group submissions
  - 10 data sets
- **Need more participation**
  - Lots more scatter from full workshop

ONERA OAT15A Airfoil: $\alpha = 1.5°$



Test Environment

- **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

Test Environment Look Ahead

- **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

Working Groups Update

- **DPW Centric**
  - Source of Scatter Working Group
  - Buffet Working Group
- **AePW Centric**
  - High Angle Working Group
  - Large Deformation Working Group
  - High Speed Working Group
- **Hybrid**
  - Static Deformation Working Group
  - Buffet Working Group

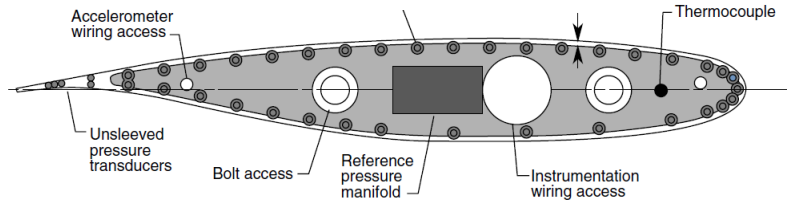
High Angle – Background

- **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)

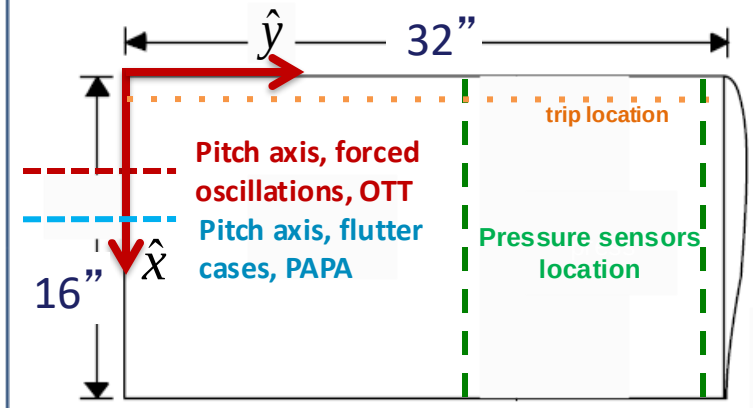
High Angle – Configuration / Data

BSCW inside Transonic Dynamics Tunnel test section

Airfoil section is SC(2)-0414



Cross-section at 60% span, showing the layout of the unsteady pressures.



Model planform. Dimensions are in inches.

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

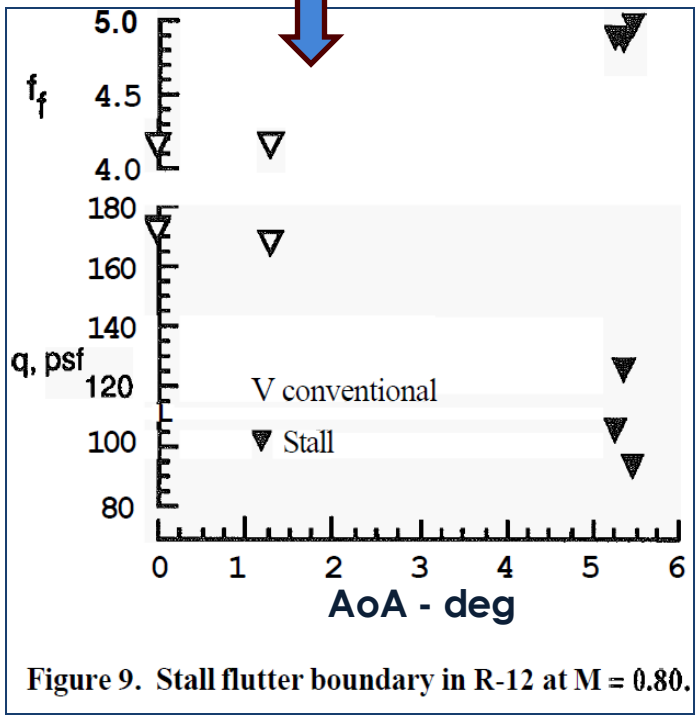


Figure 9. Stall flutter boundary in R-12 at M = 0.80.

High Angle – Workshop Cases

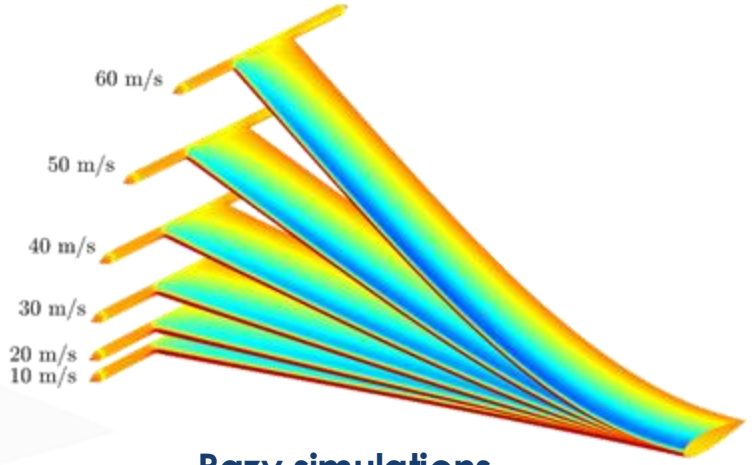
- AePW-1:
  - Steady-rigid and forced-oscillation cases at Mach 0.85, AoA = 5° ✓
- AePW-2:
  - Forced-oscillation case at Mach 0.70, AoA = 3° ✓
  - Flutter prediction at Mach 0.74, AoA = 0° ✓
  - Unsteady-rigid, forced-oscillation, and flutter cases at Mach 0.85, 5° ✓ ✓ ✓
- AePW-3:
  - Flutter prediction at Mach 0.80, AoA = 5° ✓
  - Shock-buffet case at Mach 0.80, AoA = 5° ✓

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

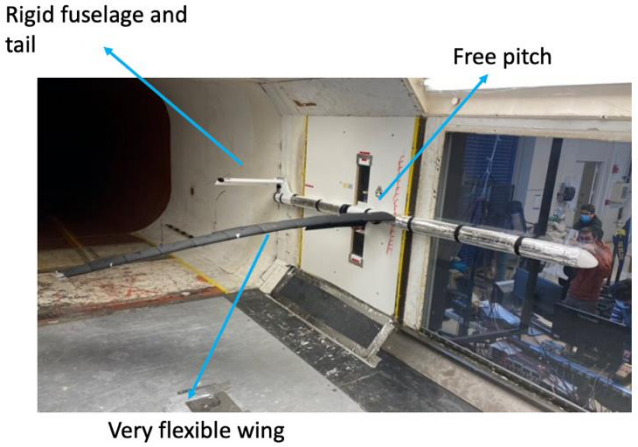
- **AePW-4: Mandatory case**
  - **Flutter prediction at Mach 0.80 and angle-of-attack sweep: 0° – 6°**
- **AePW-4: Optional case**
  - **Flutter prediction at Mach 0.74, 0.76, 0.78 and angle-of-attack 3°**

Large Deformation

- **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 → change in structural stiffness → 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



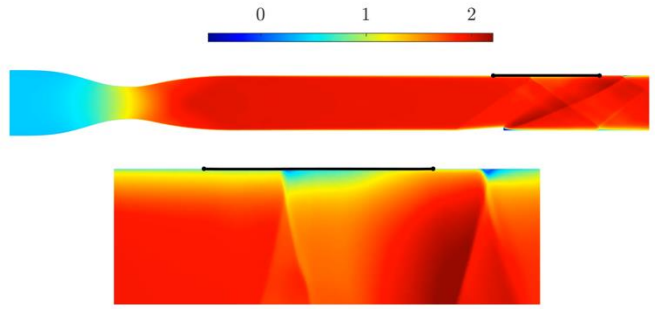
Pazy simulations



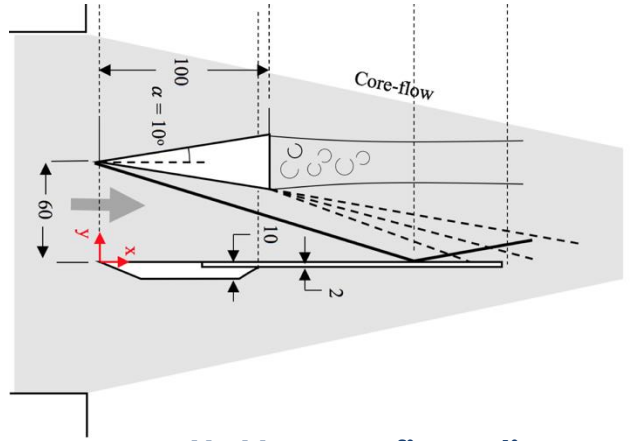
EASE configuration

High Speed

- **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

Working Groups Update

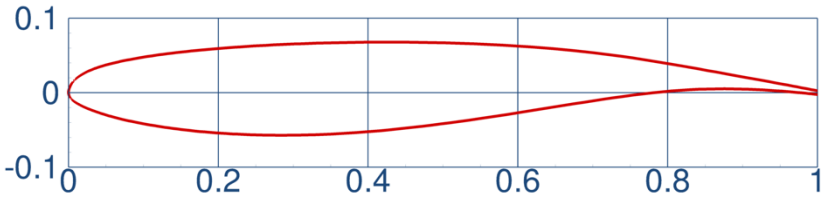
- **DPW Centric**
  - Source of Scatter Working Group
  - Buffet Working Group
- **AePW Centric**
  - High-Angle Working Group
  - Large Deformation Working Group
  - High-Speed Working Group
- **Hybrid**
  - Static Deformation Working Group
  - Buffet Working Group

Static Deformation

- **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



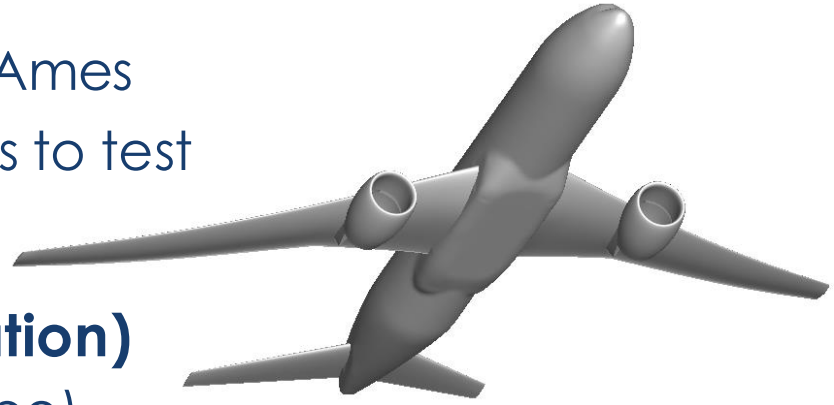
ONERA OAT15A Transonic Airfoil

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

Static Deformation Look Ahead

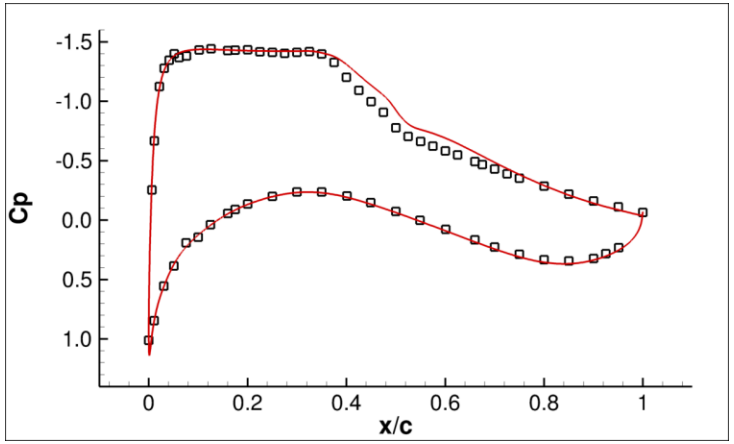
- **Test Case 1b (NASA CRM FEM Validation)**
  - Validation data will be collected in the future
    - NASA CRM Model not available until December to conduct static load and tap tests
- **Test Case 2 (CRM Wing/Body Deformation)**
  - NASA CRM geometry (initialize from unloaded wing shape)
  - NASA CRM 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)

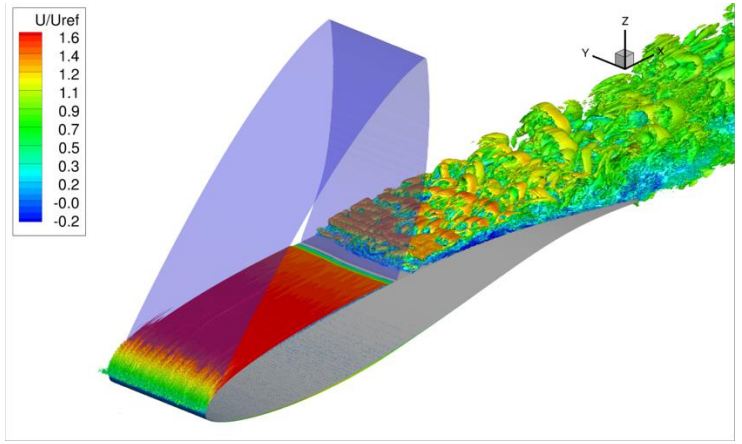
NASA CRM Structural Model



Buffet – Overview

- **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

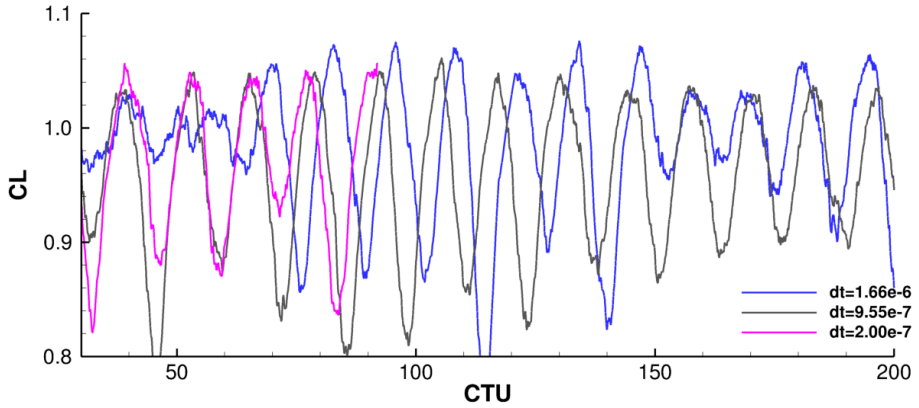




Credit (both): Jeff Housman, NASA Ames

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



Credit: Jeff Housman, NASA Ames

- **Goal is to inform later analysis and not necessarily exhaustively study the solutions (to be done by the Scatter Working Group)**

Buffet Look Ahead

- **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

Key Questions

- **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

Website Content

- **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


AIAA
SHAPING THE FUTURE OF AEROSPACE