AePW-4 Kickoff Meeting

January 7th, 2024

AIAA SciTech Forum

Agenda

- AePW goals and motivation
- Organizing Committee
- AePW history
- AePW-3 working groups
- Transition to AePW-4

AePW Goals and Motivation

- 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?
  - How can we understand the reasons for why our solvers may fail?
  - Can we establish best-practices for using aeroelastic solvers?
  - Can we establish uncertainty bounds for computational results?
  - Can we specify requirements on future validation experiments?
- What computational and experimental areas of research need further development?

Organizing Committee

- Eric Blades, ATA Engineering
- Carlos Cesnik, University of Michigan
- Pawel Chwalowski, NASA LaRC
- Adam Jirasek, USAFA
- Jeff Ouellette, NASA LaRC
- Rafael Palacios, Imperial College London
- Daniella Raveh, Technion
- Markus Ritter, DLR
- Walt Silva, NASA LaRC
- Bret Stanford, NASA LaRC

AePW History

- AePW-1 (Honolulu, 2012)
  - https://c3.ndc.nasa.gov/dashlink/static/media/other/AEPW.htm
  - Focus on transonic unsteady aerodynamics of rigid wings, forced oscillations (no flutter)
  - Rectangular Supercritical Wing (RSW), Benchmark Supercritical Wing (BSCW), HIRENASD
- AePW-2 (San Diego, 2016)
  - https://nescacademy.nasa.gov/workshops/AePW2/public/
  - BSCW flutter: an easy case (Mach 0.74, 0 deg. AoA), and a really hard blind case (Mach 0.85, 5 deg. AoA)
- AePW-3 (National Harbor, 2023)
  - https://nescacademy.nasa.gov/workshops/AePW3/public/
  - Split into four distinct working groups

AePW-3 Working Groups

1. High Angle Working Group (HAWG)
   - Led by Pawel Chwalowksi (NASA)
   - Continuation of AePW-2: focus on BSCW transonic flutter and buffet

2. Large Deflection Working Group (LDWG)
   - Led by Markus Ritter (DLR)
   - Focus on large structural deflections of a subsonic high aspect ratio wing (Pazy wing, Technion)

3. Flight Test Working Group (FTWG)
   - Led by Jeff Ouellette (NASA)
   - Focus on body freedom flutter mechanisms of the X-56A

4. High Speed Working Group (HSWG)
   - Led by Eric Blades (ATA)
   - Focus on supersonic and hypersonic FSI: RC19 test case (AFRL), and the HyMax test case (UNSW)

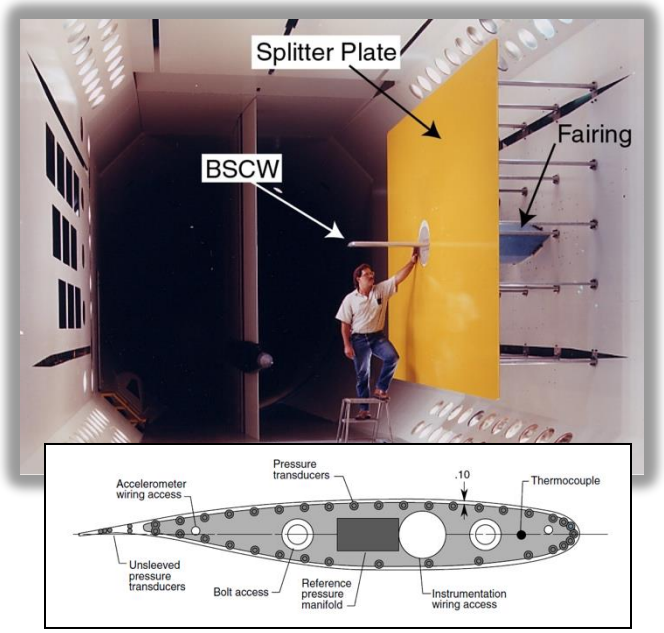
Transition to AePW-4…

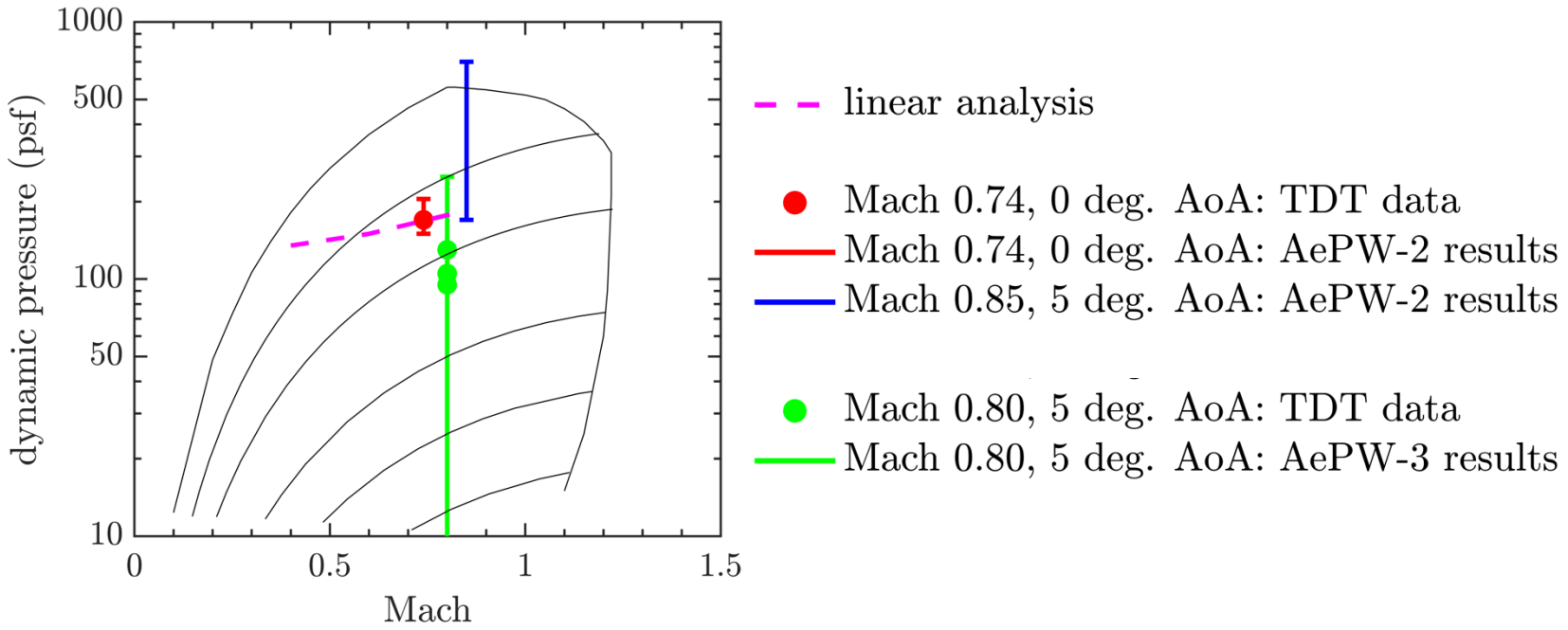
- We will have two joint working groups with DPW-8:
  1. Static Aeroelastic Deformation Group
  2. Unsteady Aerodynamic and Buffet Group

- What working groups do we want entirely under the AePW umbrella?
  - Which of the four AePW-3 WGs has enough momentum to continue on for another cycle (need workshop participation and leadership)?
  - Is there interest in starting new working groups, and/or looking at new configurations?
  - Are there efforts that are of interest to the community, but cannot be completed in time for the AePW-4 workshop (summer 2025)?

- If there are no AePW-only WGs for AePW-4, that's OK…

High Angle Working Group





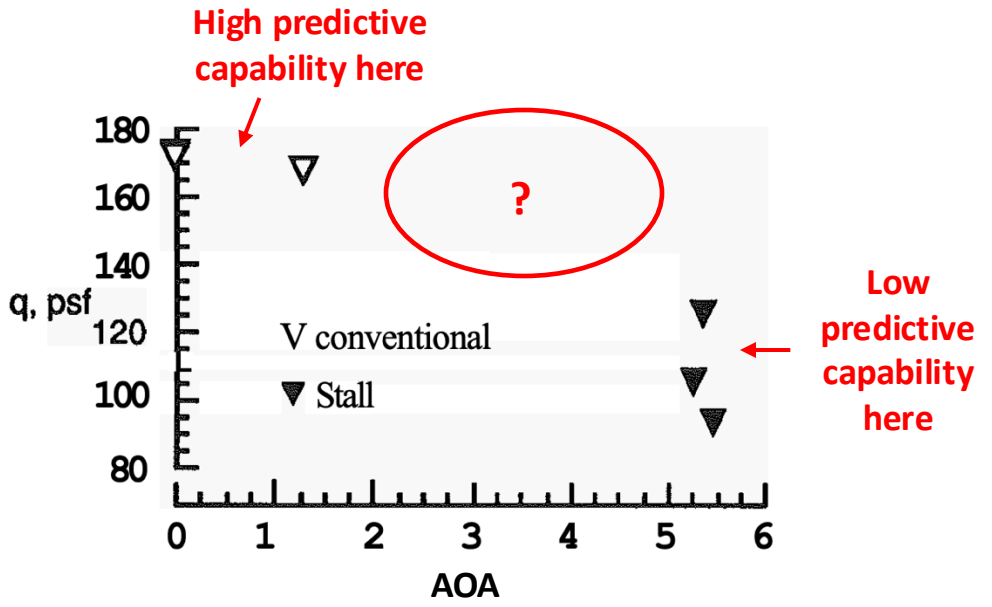
- Large spread in BSCW flutter predictions from AePW-3 (though not as bad as AePW-2)
- What have we learned?
- We need more experimental data: more flutter data points, and more on- and off-body flow data at each flutter point

The Future of the HAWG-Flutter (1)

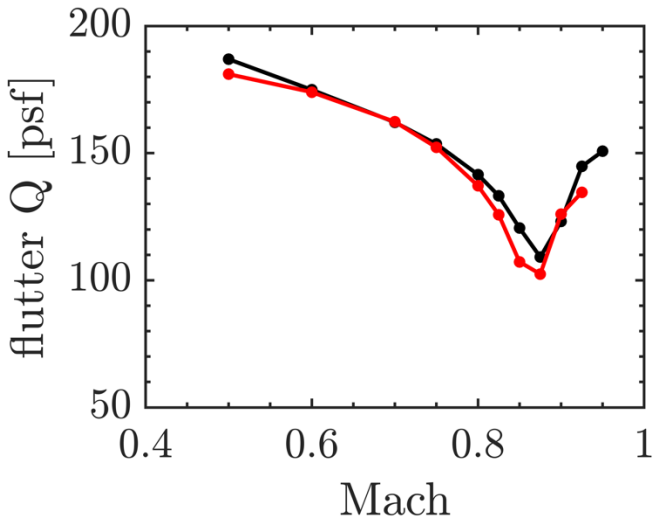
- Rather than focus on isolated flow conditions for flutter, could/should we focus on sweeps?
  - Mach-sweeps: transonic flutter dips
  - AoA-sweeps
- Positives:
  - Running cases that gradually span from “easy” to “hard” may help us better understand why our solvers gradually start to fail
- Negatives:
  - Increases the workload on each WG participant
  - What test cases have enough experimental flutter data to qualify?

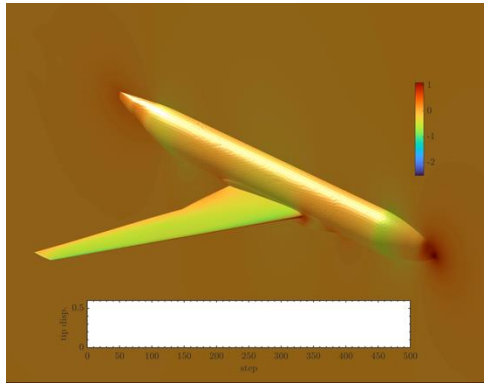
The Future of the HAWG-Flutter (2)

- Existing 1990's BSCW data is too sparse
- BSCW will be re-tested in the TDT (currently scheduled for early CY 2025)
  - Should we run blind computations in anticipation of that data?



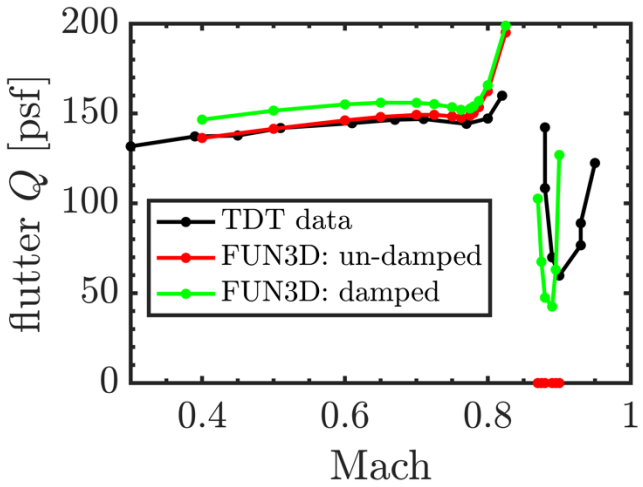
- We are working to design/fab an aeroelastic CRM (currently on the TDT schedule for sometime in CY 2026)
  - May provide another nice tie-in to DPW
  - Should we run blind computations in anticipation of that data?





Alternative Transonic Flutter Datasets?

- Benchmark-0012 Wing?
  - Mach- and AoA-sweep TDT flutter data from the 1990's
  - Very little steady/unsteady pressure data
- MAVRIC?
  - A semispan wing/body tested numerous times in the TDT
  - Will be partially re-fabbed and re-tested in early CY 2024
  - Goal is to map out flutter dips at multiple AoA
  - No pressure data
- Other cases?



B0012

MAVRIC

Transonic Control Surface Aerodynamics

- Transonic flows over a gapped control surface is a big current challenge
  - Steady or unsteady control surface rotations
  - Rigid or aeroelastic wing
  - Open- or closed-loop
- BACT wing (Benchmark Active Controls Technology)
  - Yet another benchmark model tested in the TDT in the 1990's
  - Relatively few CFD comparisons since then
- In theory there is a ton of BACT data (rigid/flexible mounts, different control surface combinations, ASE, etc.)…
  - …but the exact condition and fidelity of the dataset is uncertain

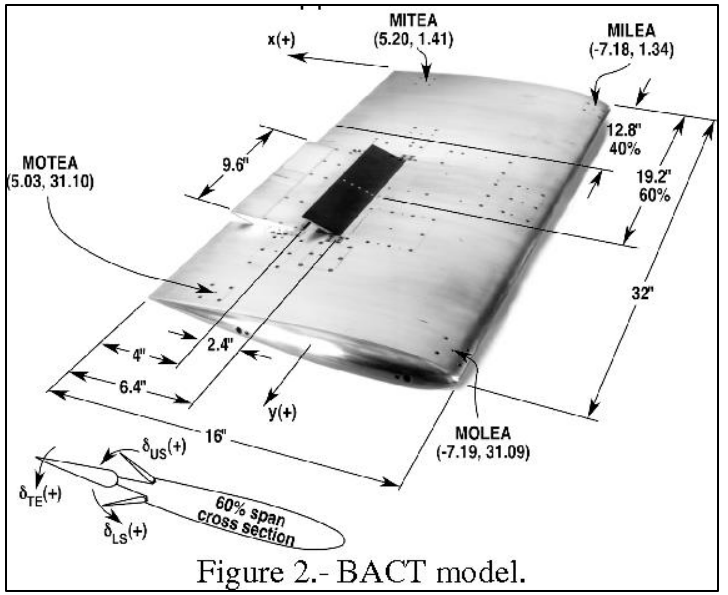
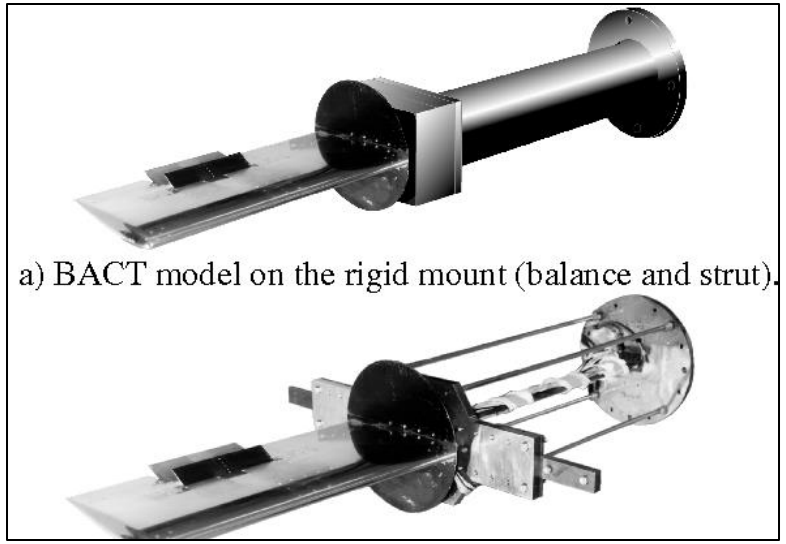
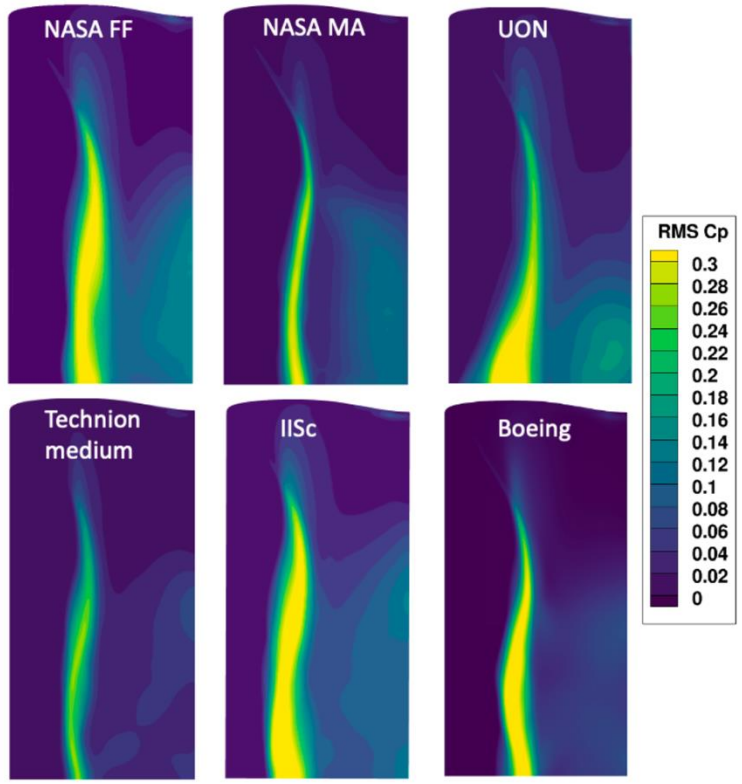


Figure 2.- BACT model.


a) BACT model on the rigid mount (balance and strut).

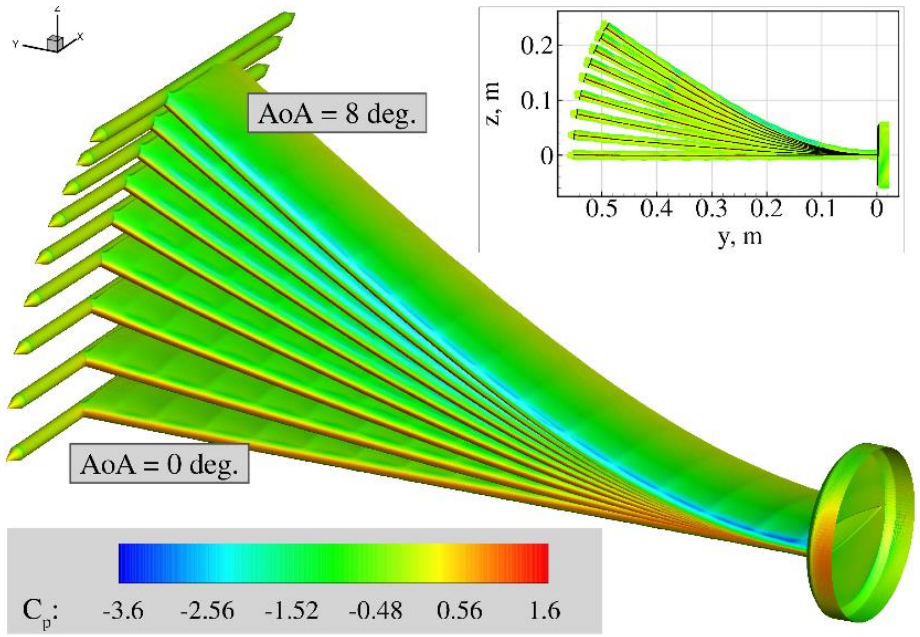
The Future of the HAWG-Buffet

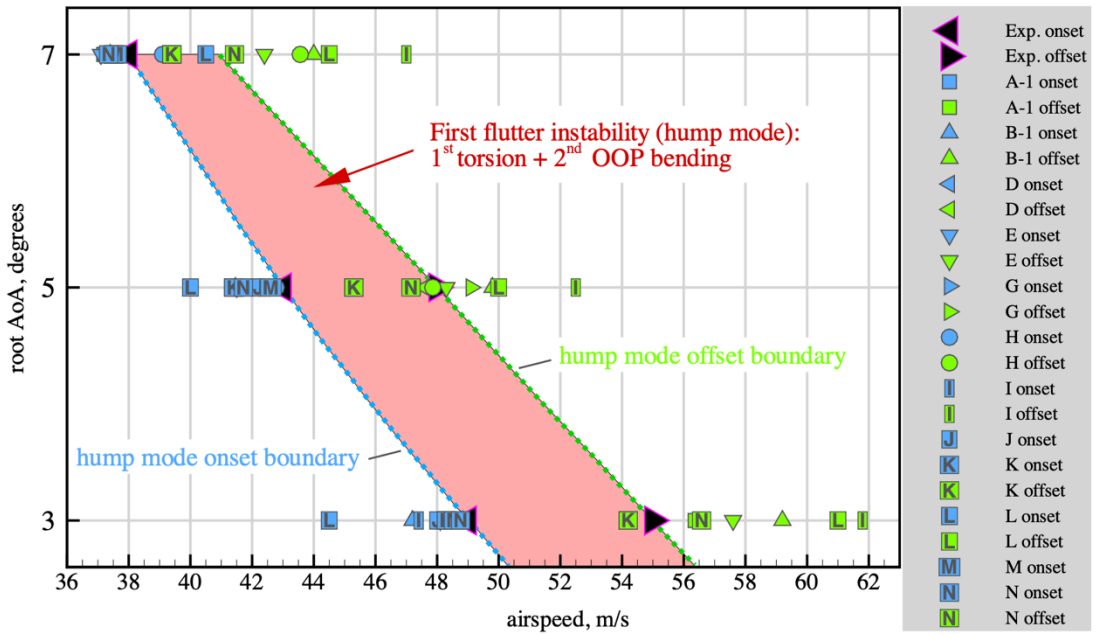
- In addition to the flutter case, AePW-3 had also considered a buffet case of a rigid BSCW model:
  - Mach 0.8, 5 deg. AoA: this AoA is well-beyond the buffet onset condition
- Similar to flutter, buffet predictions may benefit from a more granular view:
  - Can we predict the buffet onset boundary: AoA - vs - Mach?
  - Can we predict buffet growth beyond the onset boundary?
  - What test cases have enough experimental buffet data to qualify?
- The rigid BSCW will be re-tested in the TDT (currently scheduled for early CY 2025)
  - Should we run blind computations in anticipation of that data?
- Alternatively, is the joint-DPW buffet activity enough buffet research for one workshop?



Open Discussion

The Large Deformation Working Group



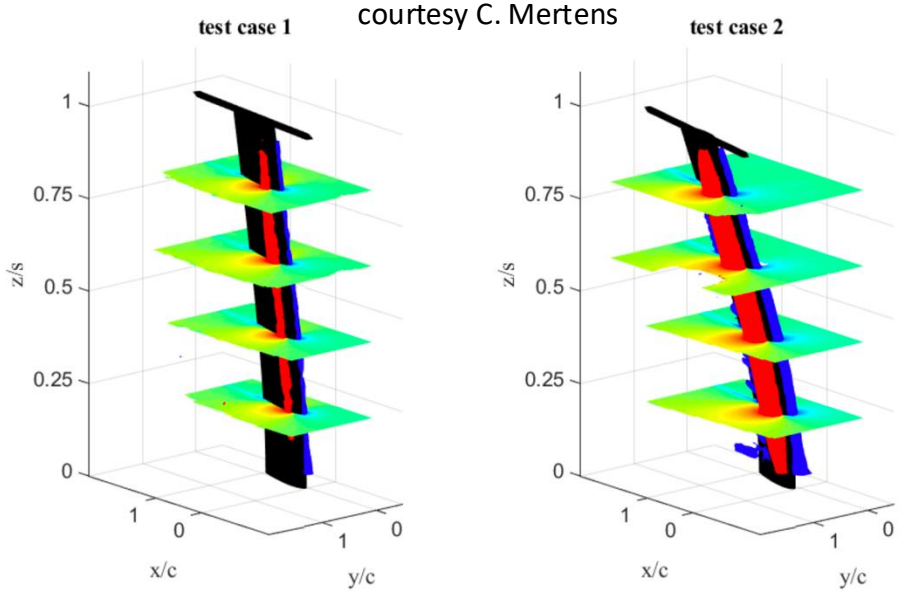


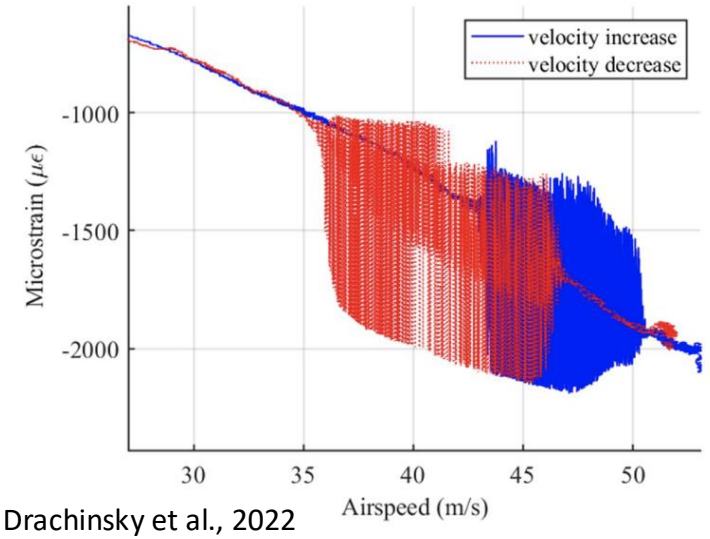
- Pazy wing: AoA-dependent hump-mode flutter boundary driven by geometric nonlinearities
- Aerodynamics are mostly linear: CFD can be used, but not required
- Reasonable agreement between the participants' results and the experimental data
- This WG was the most popular of the 4 WGs

The Future of the LDWG

- New leadership is needed for the LDWG
- Gust response: Christoph Mertens (Delft / NLR) has obtained Pazy response data due to a periodic gust
  - Is this the most straight-forward extension of the AePW-3 / LDWG activity? Same configuration, (mostly) the same modeling tools, but new physics
- Pazy LCO response data from Technion
  - Some post-flutter data exists (and more could be obtained?)
  - Subcritical LCO possibly driven, in part, by dynamic stall
  - Another interesting/useful extension from AePW-3, but: how many participants have the tools for dynamic stall?
- Technion is also working on a swept Pazy wing
  - Stronger aeroelastic coupling than the unswept version

courtesy C. Mertens

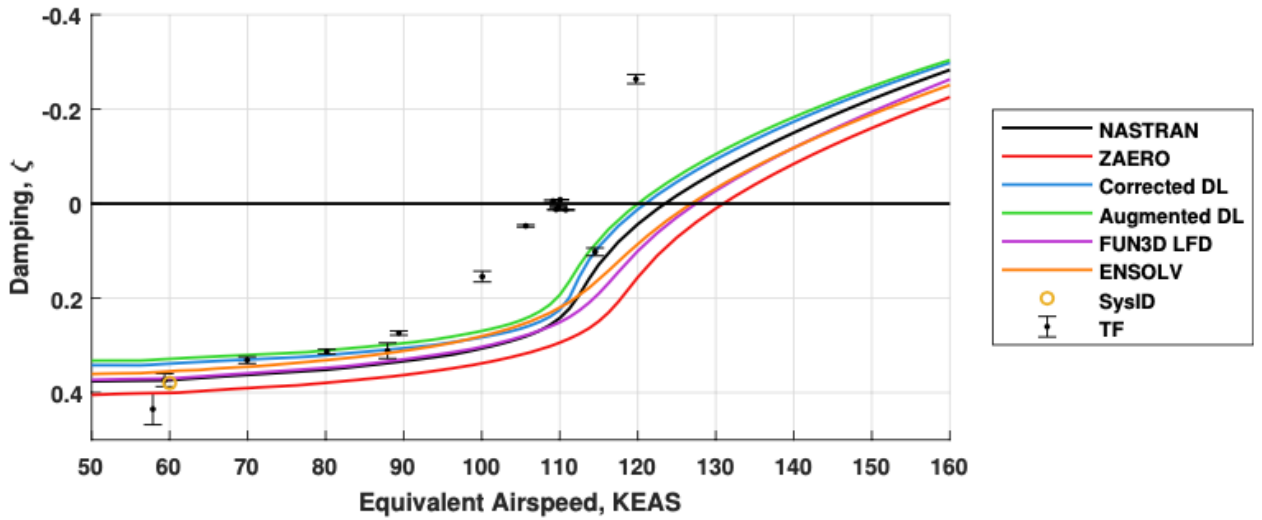




Drachinsky et al., 2022

Open Discussion

The Flight Test Working Group



- Body freedom flutter mechanisms of the X-56A
  - Rigid body modes are a challenge for the CFD solvers
- Comparisons via GAFs, aerodynamic work/energy, and root-locus plots for 4 different fuel states
- Reasonable agreement with test data, though flutter speed is over-predicted
- Simplified X-56A geometry used here: no landing gear, no engines

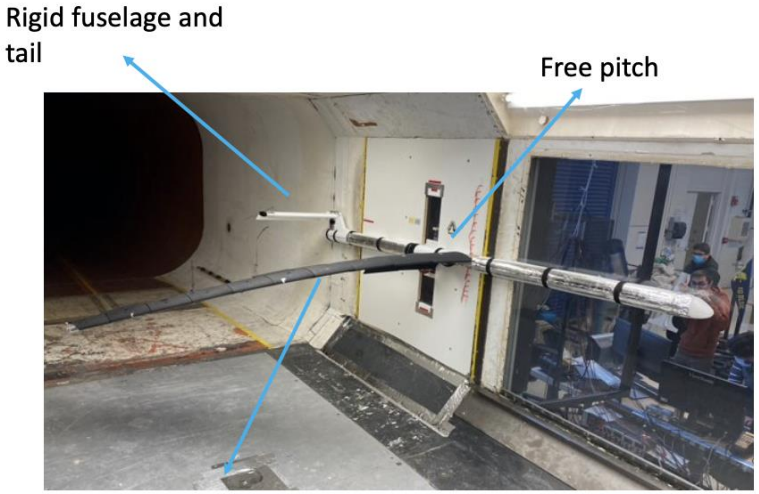
The Future of the FTWG

- Is there additional X-56A data that could/should be looked at for AePW-4?
  - Was there enough AePW-3 participation to warrant a continuation?

- Possible alternative configurations that would fit under FTWG (though they could also fit under LDWG, or some newly-branded WG):

  - Michigan's EASE configuration: semi-span, high-aspect-ratio model on a PAPA support
    - There is a build-up of physics, culminating in ASE load alleviation

  - Technion and Michigan's A3TB configuration: wind-tunnel and flight test versions
    - The linear structure may limit interest in this case
    - The flight test version experienced BFF/LCO, but as with Pazy: how many workshop participants can handle dynamic stall?

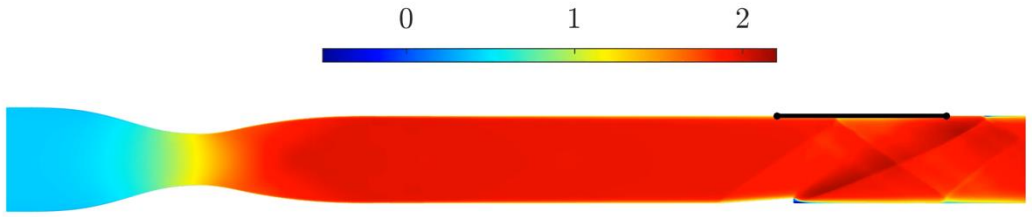


EASE configuration: courtesy U. Michigan

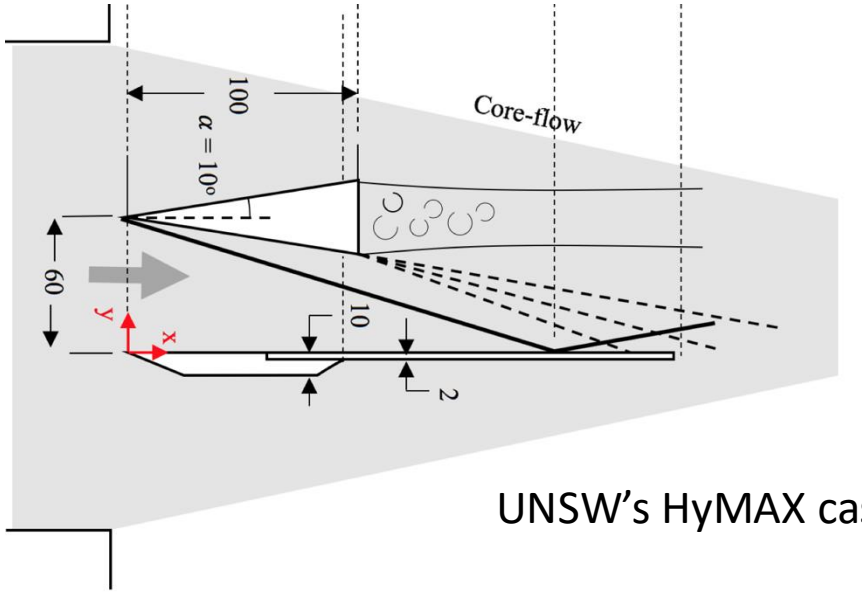

A3TB configuration: courtesy Technion

Open Discussion

The High Speed Working Group



AFRL's RC-19 test case



UNSW's HyMAX case

- RC-19: Mach-2 flow through a wind tunnel with a nonlinear flexible panel
  - Different panel temperatures, cavity pressures, and wedge angles lead to different responses (LCO, chaos)
  - This is a very challenging problem which is very sensitive to the various inputs
- HyMAX: Mach-6 flow over a flexible plate, with shock impingement
  - 2 deg. wedge (laminar), 10 deg. wedge (transitional), oscillating wedge (reach case)
  - Linear structural response
  - Relatively few participants have considered this case, to-date

The Future of the HSWG

- New leadership is needed for the HSWG

- This working group got off to a relatively late start, and had relatively fewer results at AePW-3, compared to the other WGs
- A mini-workshop for this effort was held the day before SciTech
- Continue on with this WG through to AePW-4?
  - Same test cases? New data from the same test cases? Entirely new test cases?
- Relationship with the AIAA High Speed FSI DG?

Going Forward

- Ideally, we would settle on the AePW-4 WGs in Q1 of 2024: configuration(s), leadership, test-cases, etc.
- In addition, settle on any WGs that are of interest to the community, but would not be ready in time for AePW-4 (summer 2025)
- Either way: monthly meetings for each WG
  - Monthly (bi-monthly?) meetings for the entire AePW community
- If you do not receive AePW emails, and want to, please ping me:
  - bret.k.stanford@nasa.gov