NASA LaRC Update for the Large Deformation WG

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Goals / Methods

- High-fidelity computational modeling of the unswept Pazy wing
  - Focus on limit cycle oscillations (LCO)

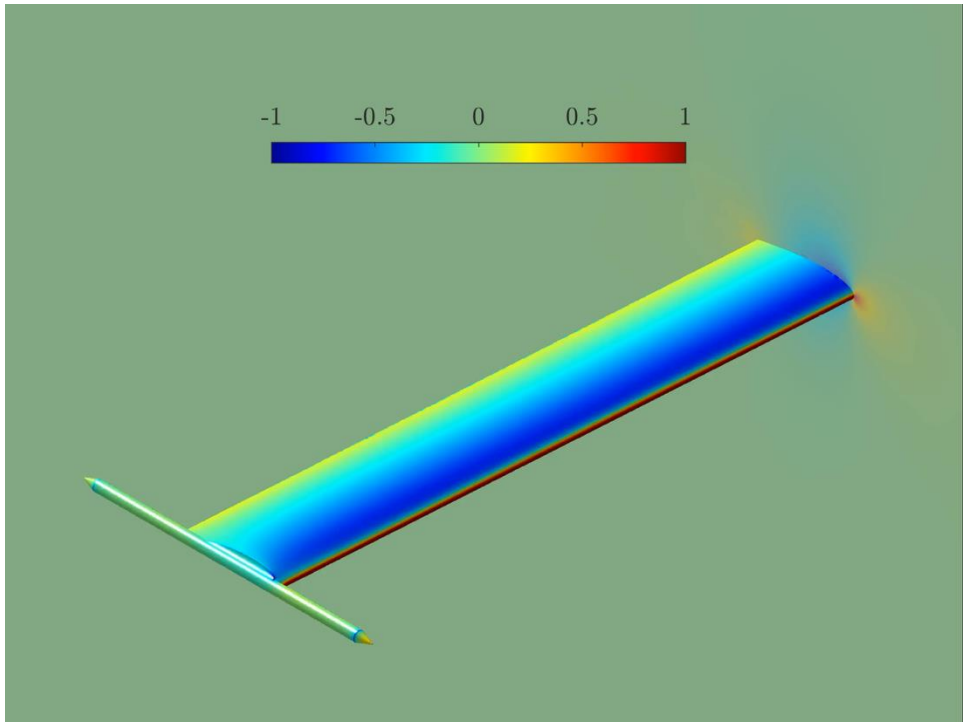
- Time-domain coupling of FUN3D and Nastran (sol-400)
  - Python-based interfacing with FUNtoFEM; load-displacement transfer with MELD
    - https://github.com/smdogroup/funtofem
  - FUN3D: unsteady finite-volume RANS solver with SA
  - Python-wrapper of sol-400 written with pyNastran
    - https://github.com/SteveDoyle2/pyNastran
    - Beam model of Pazy wing used in Nastran
  - Loose coupling: one fluid-structure pass per time step

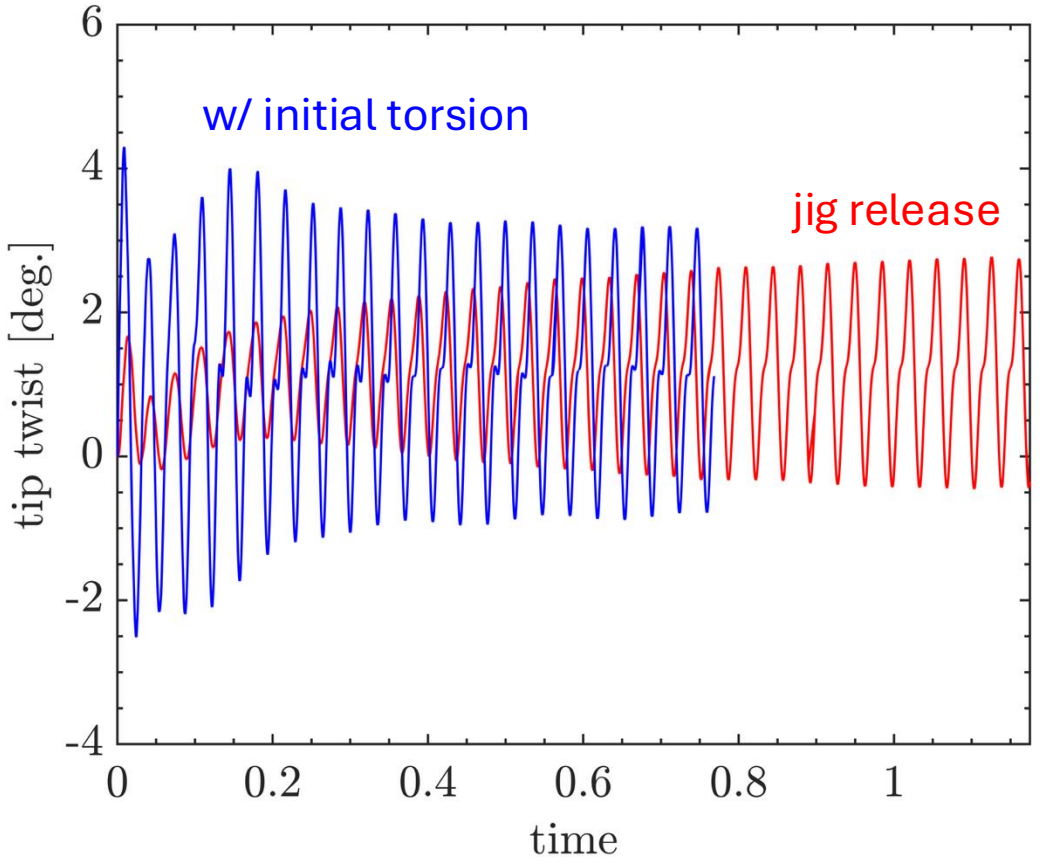
Motivation

- Why use CFD for this work?
  - All of the static and dynamic aeroelastic predictions from AePW-3 showed good agreement with experiment, when using linear panel aerodynamics
  - Relatively few have looked at computational LCO modeling, but there also the computed LCOs appear to be mostly driven by structural nonlinearities

- But, perhaps at higher AoA's, dynamic stall could play a role
- The URANS solvers used here can accurately predict some, but not too much, separated flow behavior

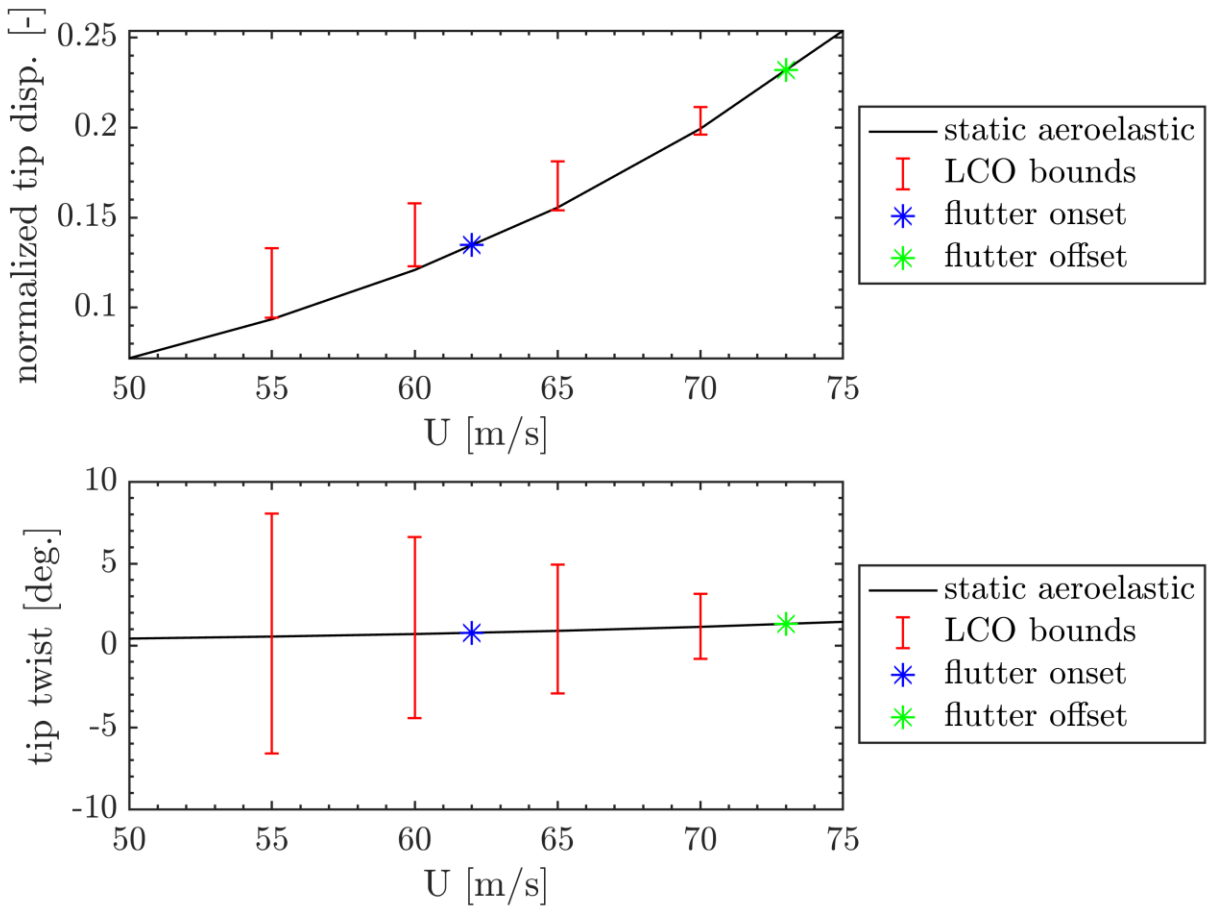
Computed Pazy LCO at 1 deg. AoA, 70 m/s





2M node RANS mesh, 300-400 time steps per LCO

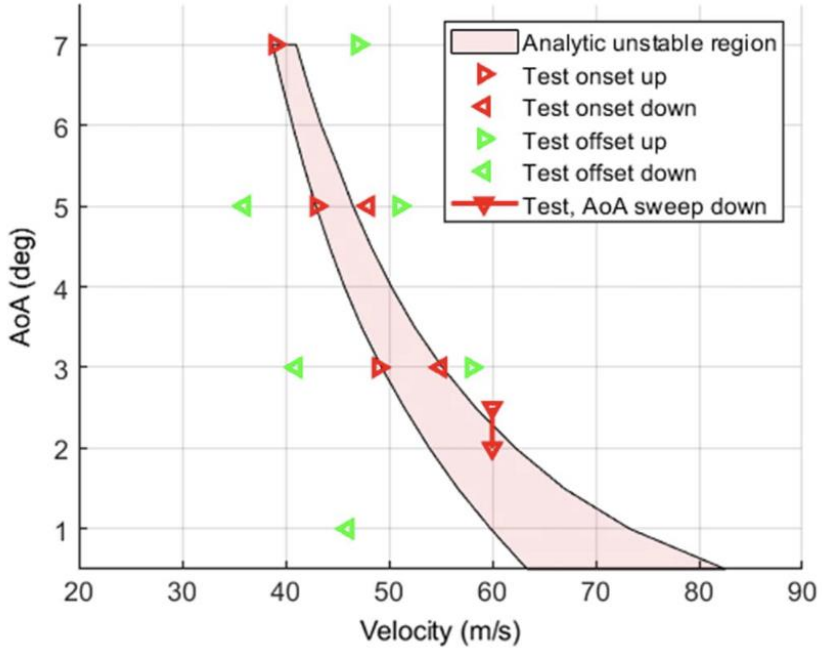
Computed Pazy LCO's at 1 deg. AoA

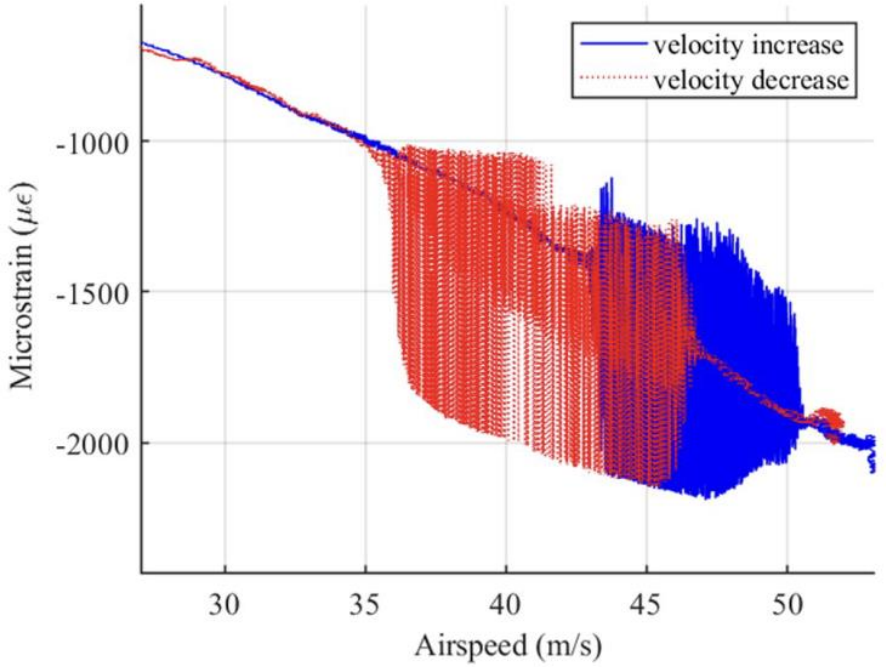


- Subcritical LCO: high-amplitude dynamics exist at velocities below the flutter onset point
- LCO dynamics monotonically decrease from the LCO-fold point up to the flutter offset
- We don't see LCO's beyond the flutter offset
- LCO dynamics are not centered about the static-aeroelastic result, particularly near the fold

Technion Experimental Data

Drachinsky et al., *AIAA J.*, 2022





- Experimental data <u>does</u> show LCO near the higher-speed flutter offset points, but that's at 3 and 5 deg.
- Our preliminary simulations are only at 1 deg.

- Experimental data <u>does</u> show LCO's that are not symmetric about the static aeroelastic result
- Particularly true at the lower-speed flutter onset
- But this data is at 5 deg., and our preliminary simulations are only at 1 deg

Next Steps

- Repeat this exercise at higher AoA's: 3, 5, and 7 deg.
  - Try to quantify the role of intermittent flow separation at the higher AoA LCOs, if any
  - Particularly at these higher AoA, need to demonstrate some level of mesh convergence

- The complete mapping of LCO's at 1 deg. AoA took several months to complete
  - Nastran license restrictions were a big part in that slowness