ITA and Embraer Aeroelasticity Cooperation in Preparation for the AEPW-4

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AVIATION 2025, Las Vegas

PEE programa ESPECIALIZAÇÃO EM ENGENHARIA

EMBRAER

AIAA SHAPING THE FUTURE OF AEROSPACE

Summary

- Presentation Objective
- Structured Collaboration
- Workshop challenges
- Introduce four methods being developed
- Conclusion

Objective

- Showcase the collaborative effort between ITA (academic) and Embraer (aircraft manufacturer) on the under developing methods to address the upcoming challenges of AEPW-4 and DPW-8

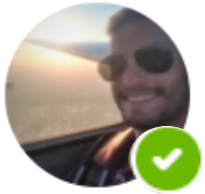
Structured collaboration

- ✓ Master degree program
- ✓ There are Academic and industrial advisors

Flávio L. Silva Bussamra
Academic Advisor

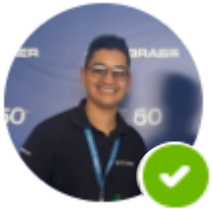
Vitor Gabriel Kleine
Academic Advisor

Angelo Antonio Verri
Industrial Advisor



Júlio Cesar S. Fernandes
Industrial Advisor

Orlando
Student / System Engineer



Withor
Student / Materials Engineer

Henrique
Student / Controls Engineer

Arthur
Student / Structures Engineer

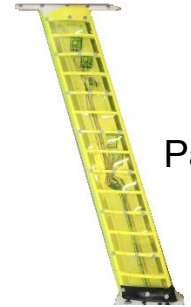
Bruno
Student / Structures Engineer

Felipe
Student / L&A Engineer

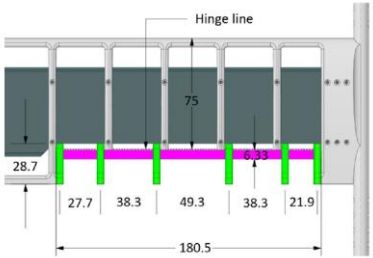
Our challenge on AEPW 4 – DPW 8

The workshop is intended to verify the capability of tool and methods in the prediction of Aeroelastic phenomenon and aerodynamics

(a) Pazy-wing *



(b) Swept Pazy-wing **



(c) Pazy-CS

Fig.1 - Large deflection workgroup AEPW-4

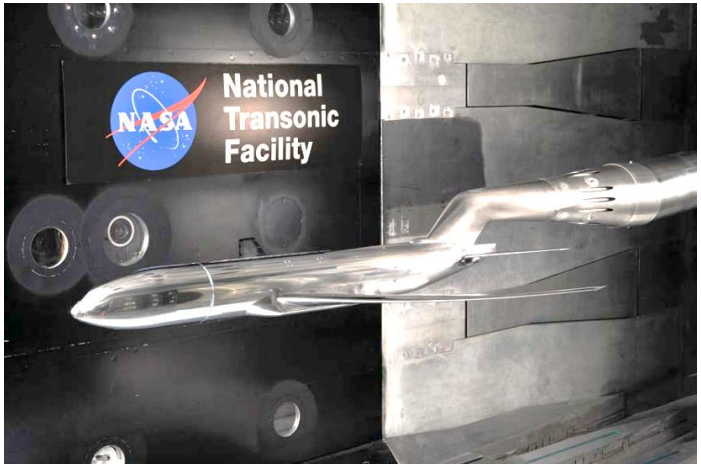
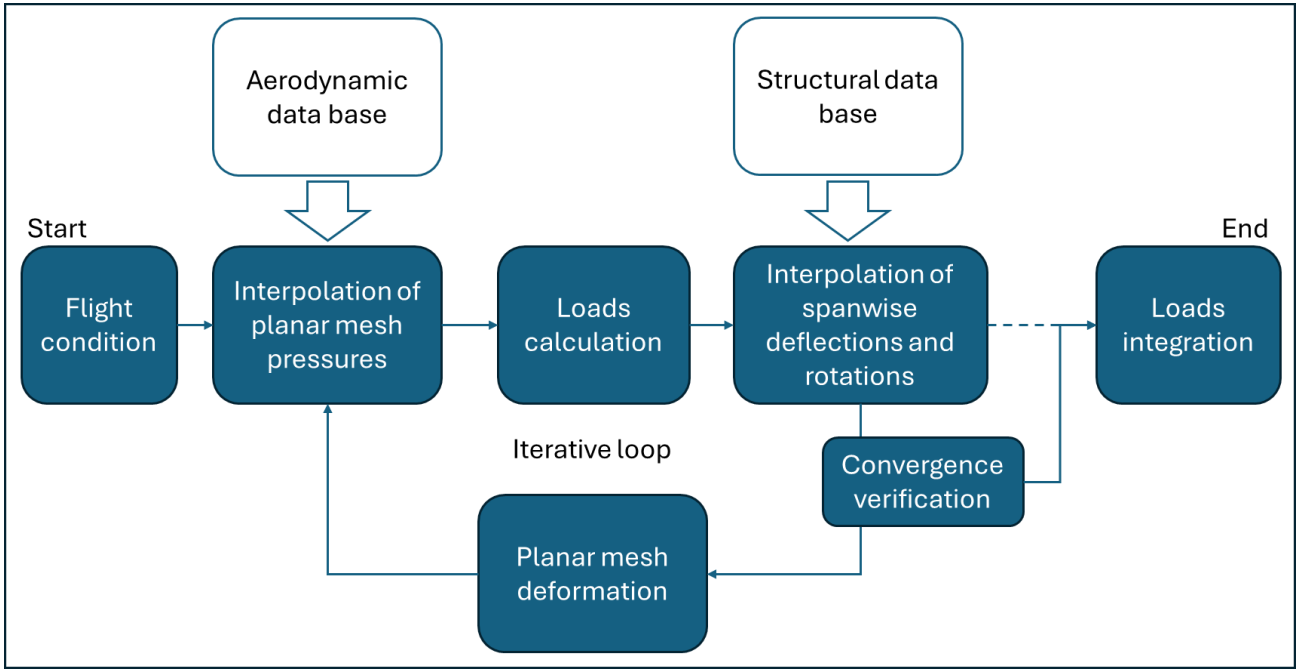


Fig. 2 -Transonic static aeroelasticity DPW-8 – CRM***

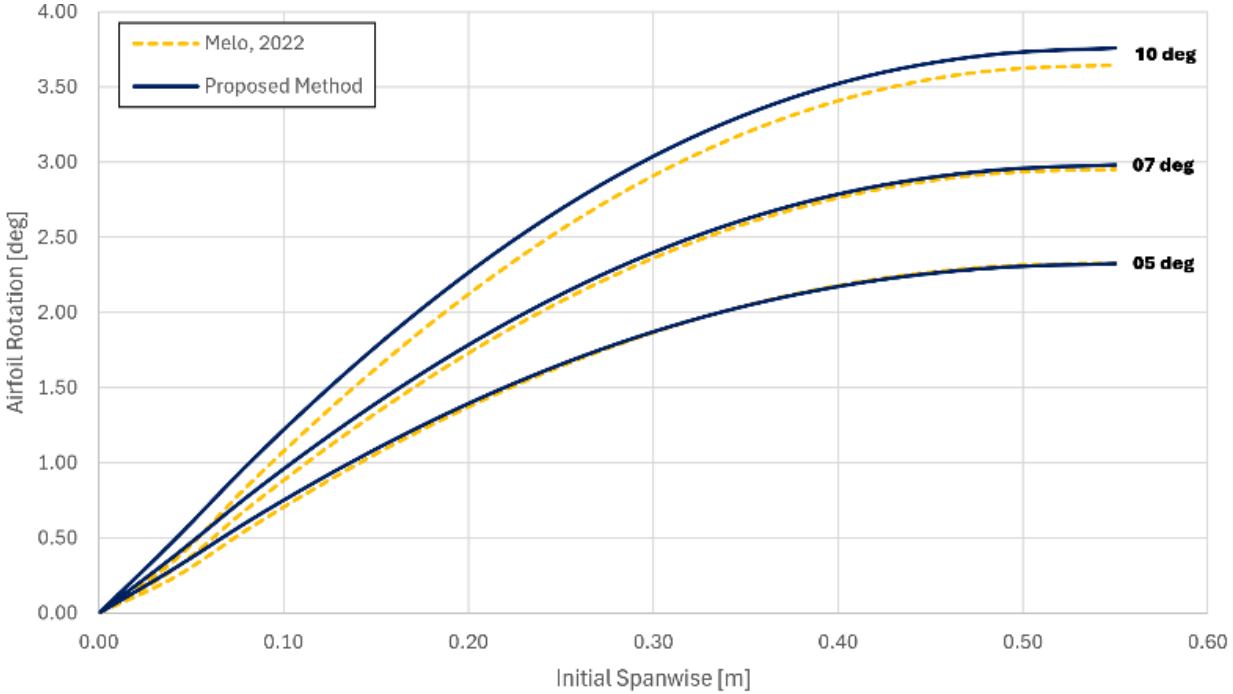
*Website for AEPW-3: https://nescacademy.nasa.gov/workshops/AePW3/
**Website for AEPW-4: https://nescacademy.nasa.gov/workshops/AePW4/
***Website for DPW-8: https://aiaa-dpw.larc.nasa.gov/

1 – Fast loads prediction

- An interpolation-based FSI method is proposed for Conceptual Design
- An aerodynamic database is coupled with a flexibility database
- Captures large displacements/rotations during static flight maneuvers



1 – Fast loads prediction



Pazy-wing at 50m/s – for multiple angles of attack

Pazy-wing evaluation:

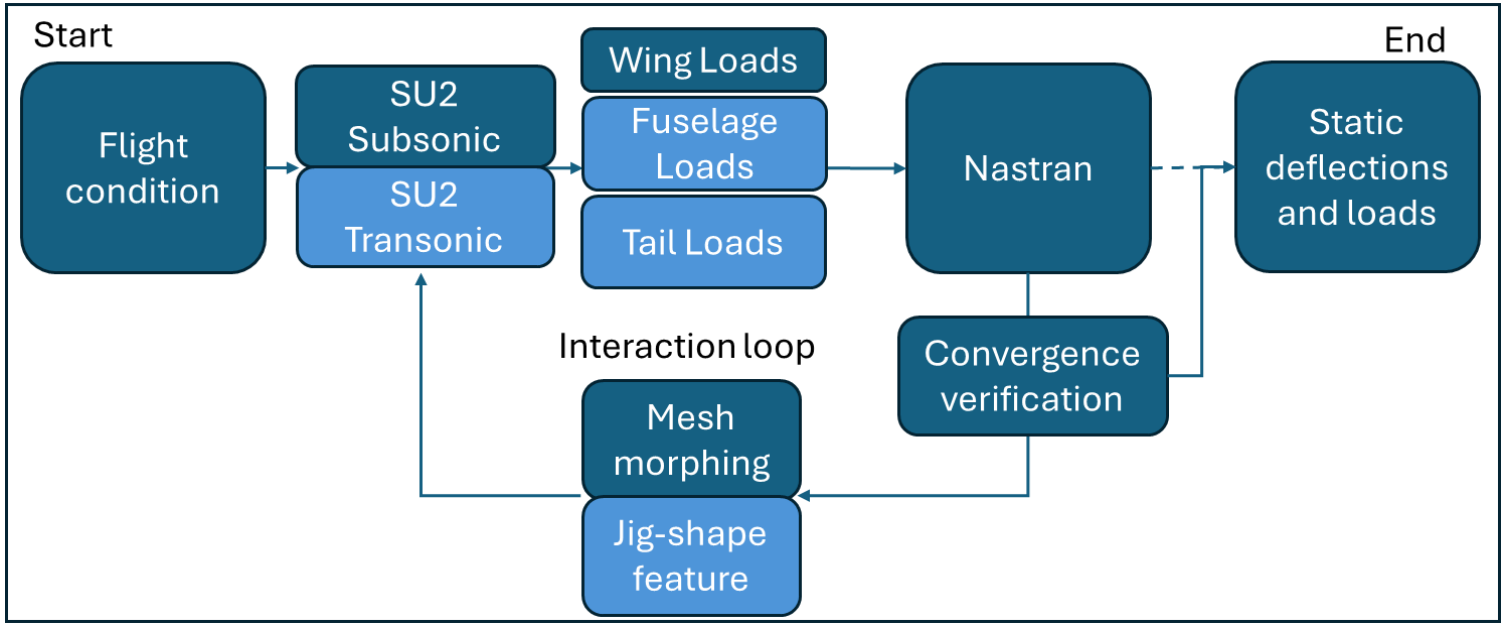
Proposed: 1.7 seconds for converging each flight condition

Mid-fidelity: 5731s seconds for converging each flight condition

(Intel® Core™ i5 and 8GB memory)

2 – SU2-Nastran FSI framework

- SU2 solves RANS equations in aerodynamics
- Nastran solves implicit static nonlinear structural equations
- Python scripts loosely couples the proposed framework
- Blocks whole aircraft deflection and Jig-shape obtention are under development



2 – SU2-Nastran FSI framework

- Coarser meshes for CFD and Structures to test the framework
- The meshes from workshop are used for final calculations

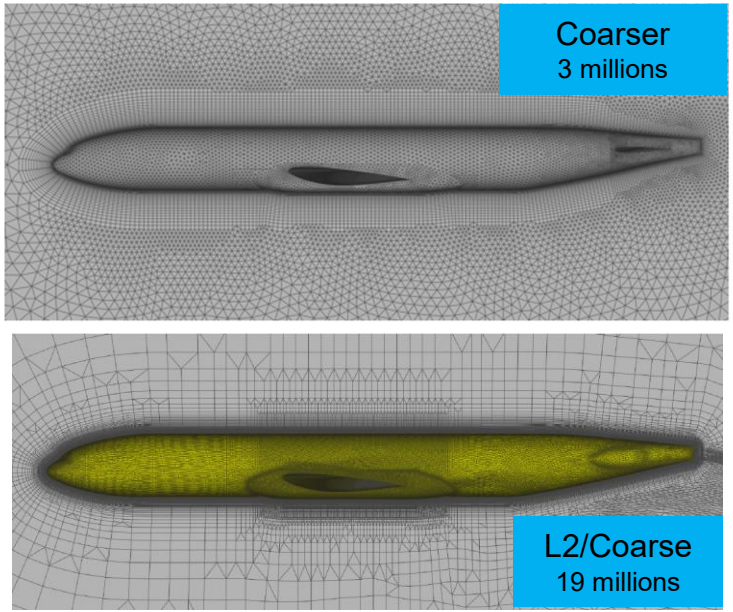


Fig. 1 – Coarser CFD mesh and L2/Coarse workshop mesh

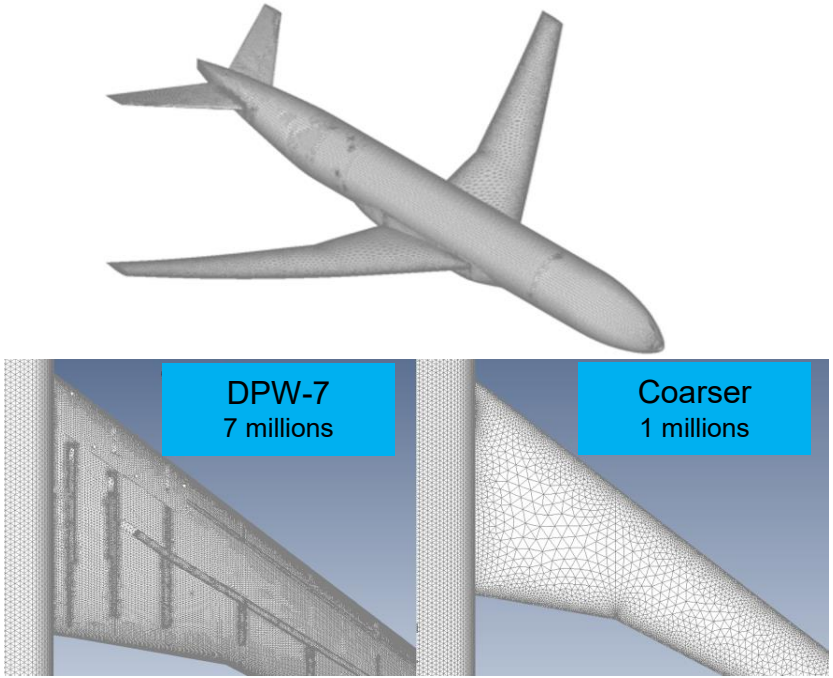
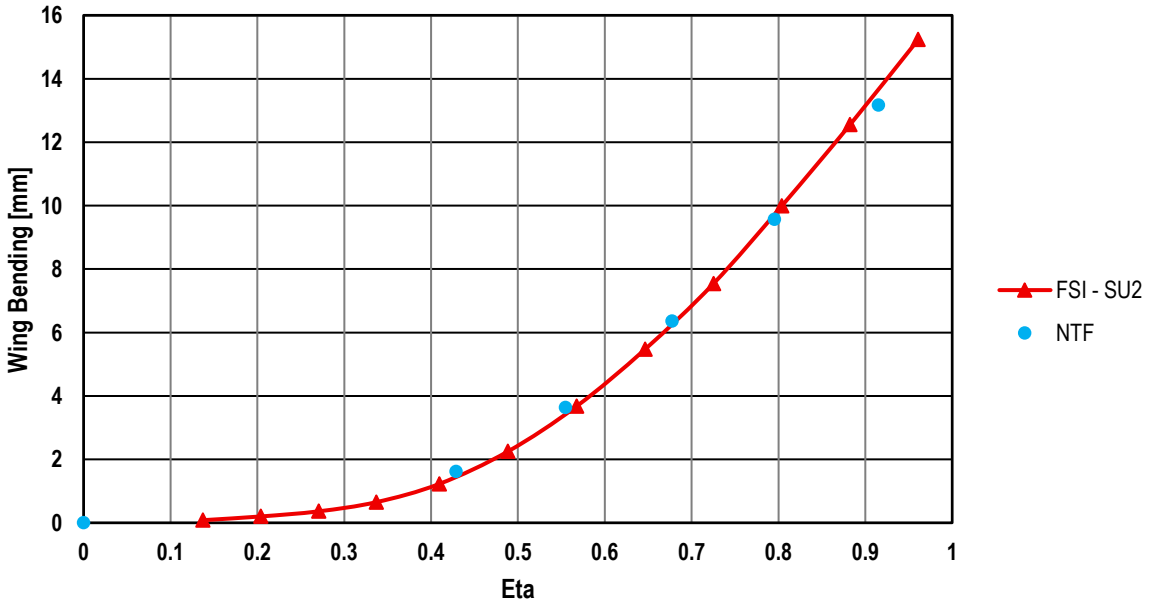


Fig. 2 – Coarse solid structural and DPW-7 mesh

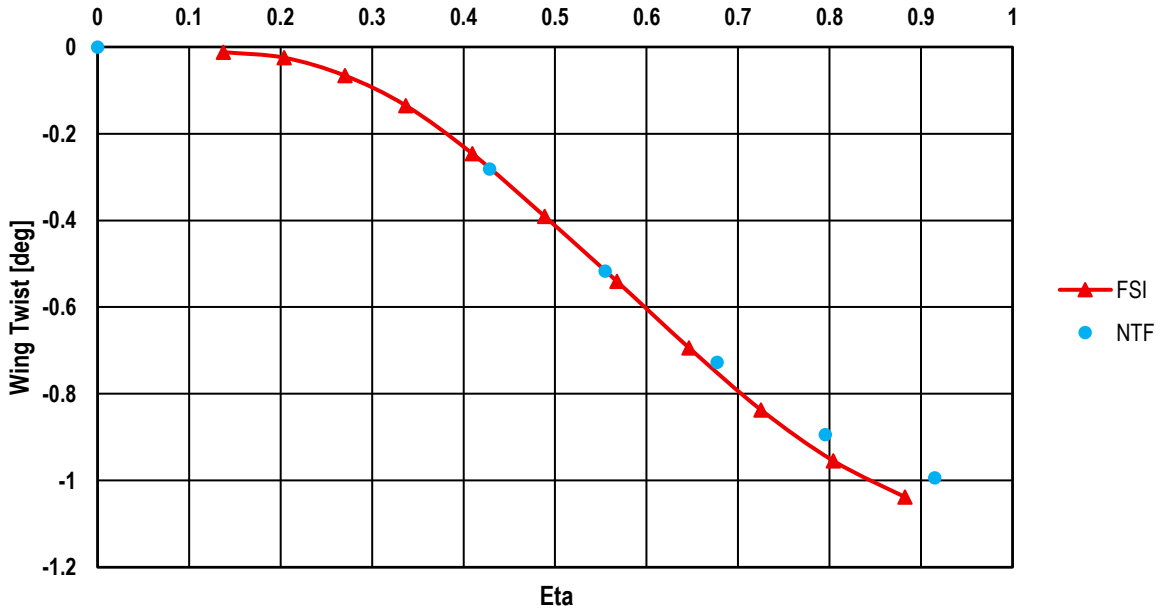
2 – SU2-Nastran FSI framework



CRM WB wing deflection in Test Case 2a [Re 5M, Mach 0.85, Cl = 0.5]

DPW8 L2/Coarse mesh for CFD. Structural model from DPW-7.

2 – SU2-Nastran FSI framework

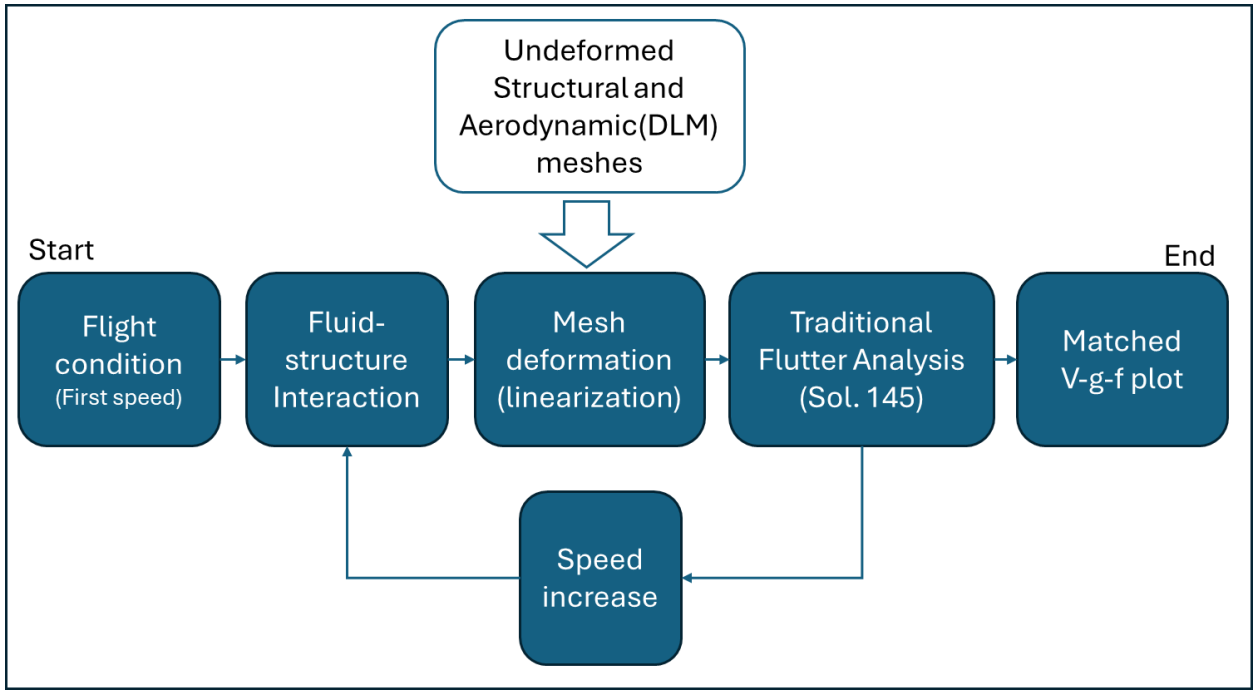


CRM WB wing deflection in Test Case 2a [Re 5M, Mach 0.85, Cl = 0.5]

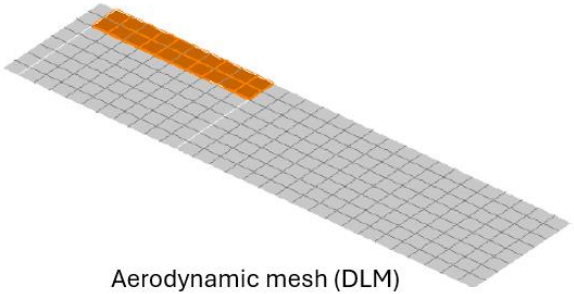
DPW8 L2/Coarse mesh for CFD. Structural model from DPW-7.

3 – Matched Flutter on balanced aileron

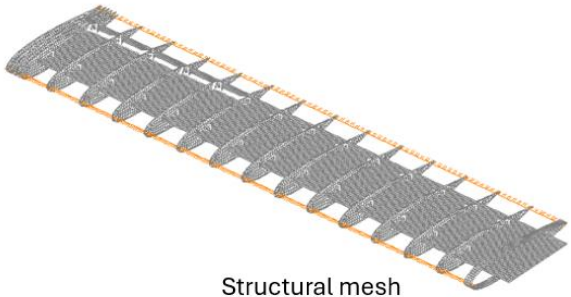
- A mid-fidelity FSI obtains the flight-shape
- Structures model with aileron and DLM model are linearized in every flight-shape
- Traditional flutter solution 145 on Nastran are made for every flight-shape



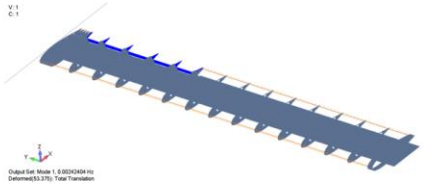
3 – Matched Flutter on balanced aileron



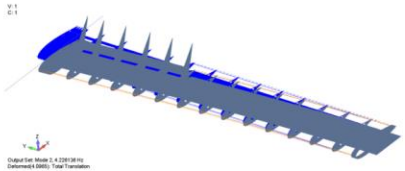
Aerodynamic mesh (DLM)



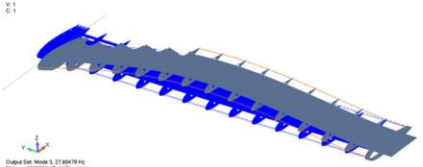
Structural mesh



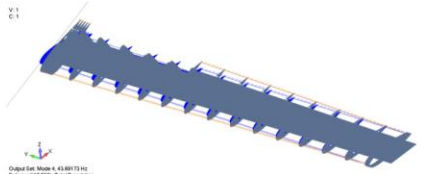
Aileron Rotational Vibration - Rigid



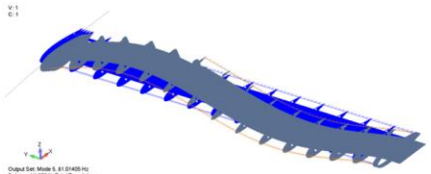
First Bending – 4.23 Hz



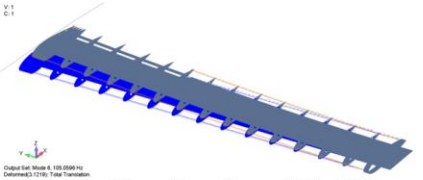
Second Bending – 27.86 Hz



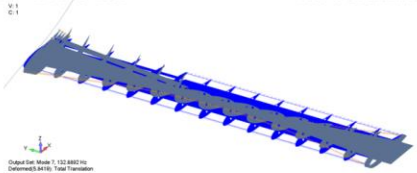
First Torsion – 43.69 Hz



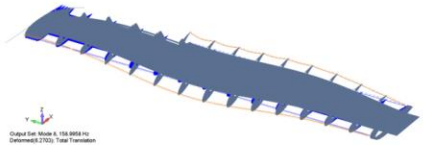
Third Bending – 81.01 Hz



In Plane Bending – 105.06 Hz

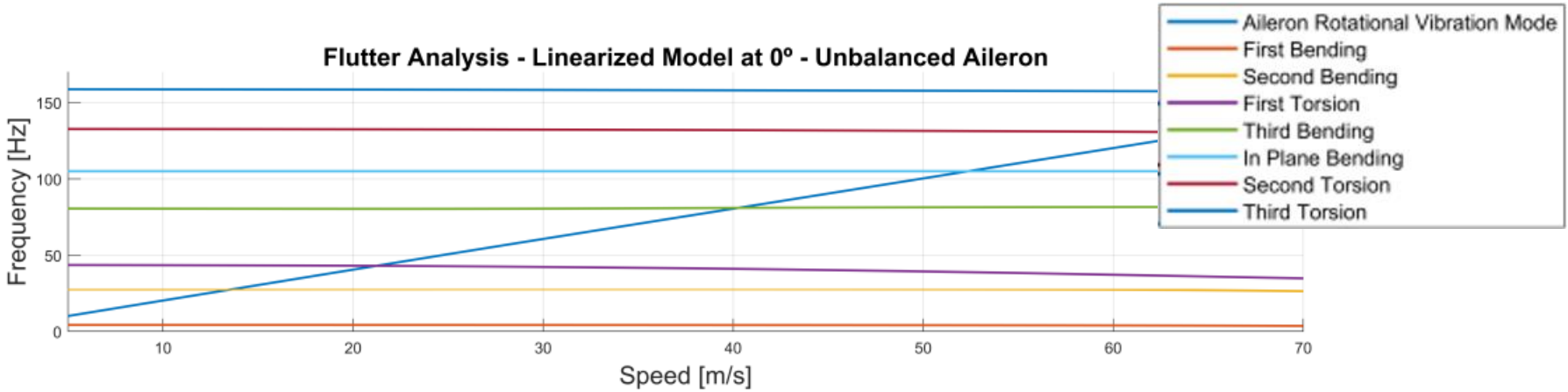


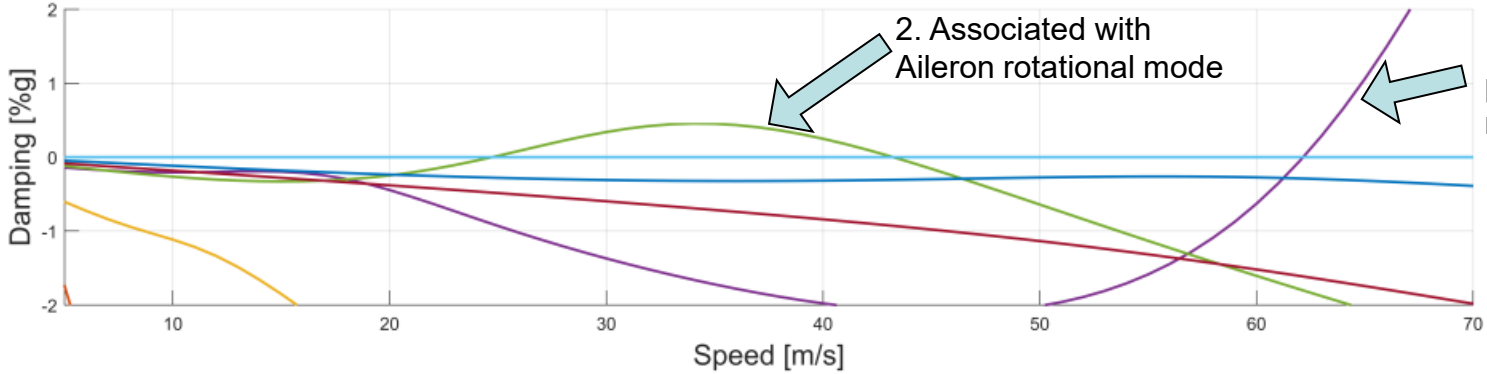
Second Torsion – 132.89 Hz



Third Torsion – 159.00 Hz

3 – Matched Flutter on balanced aileron





3 – Matched Flutter on balanced aileron

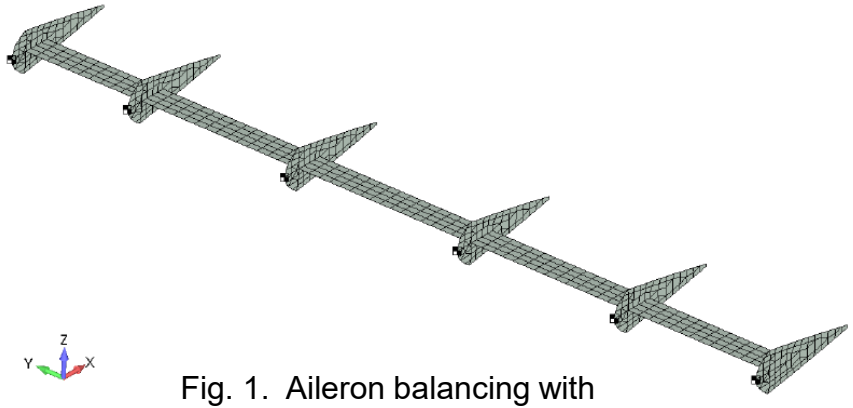


Fig. 1. Aileron balancing with mass in the Leading Edge

Is the traditional mass balancing of the aileron sufficient to prevent flutter in a very/highly flexible wing?

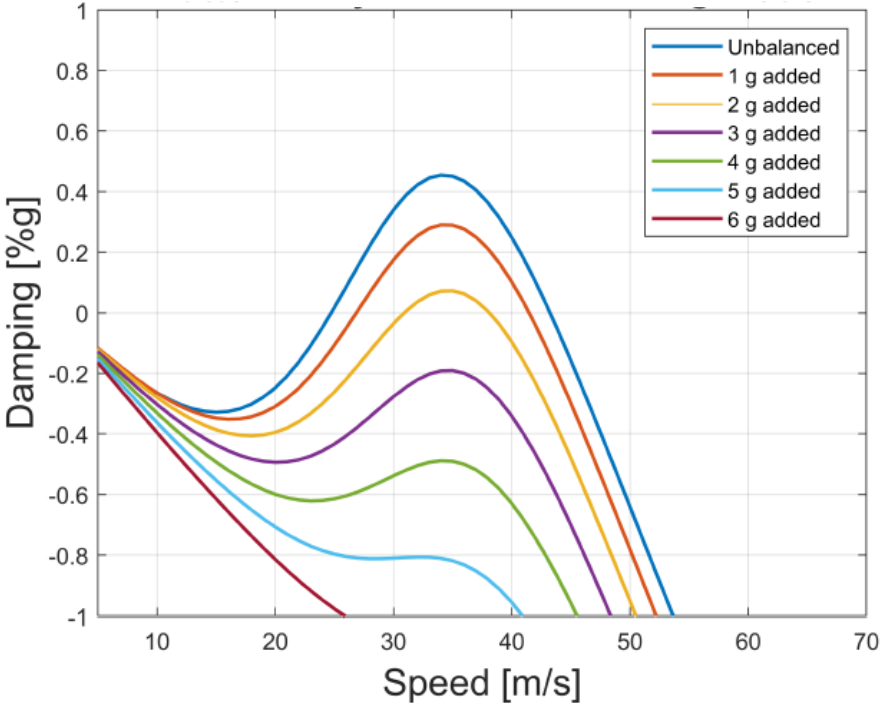
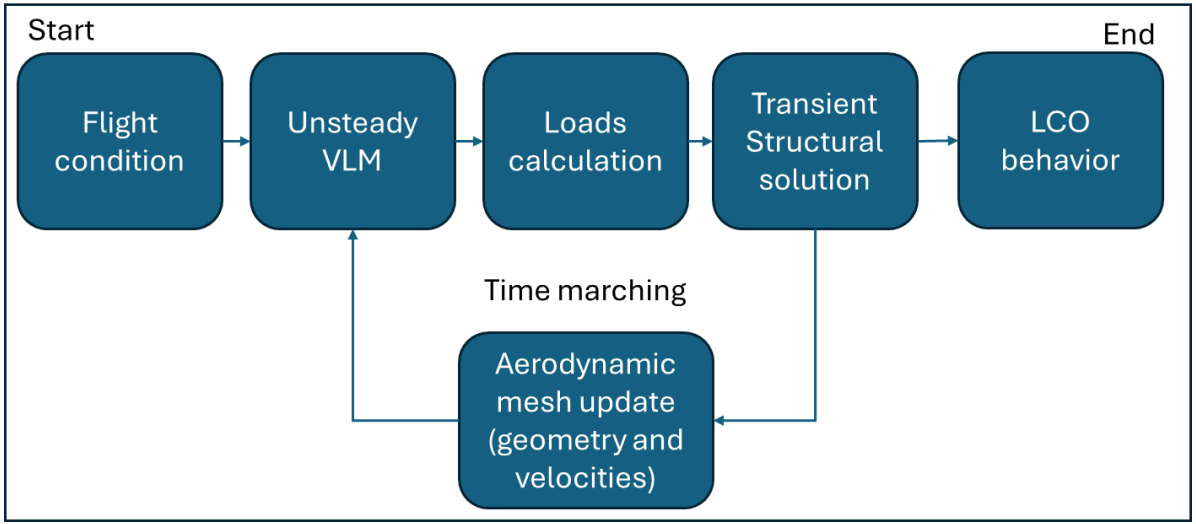


Fig. 1. Third bending - flutter prevention

4 – Transient NL FSI for LCO

- Couples an Unsteady Vortex Lattice Method (UVLM in the code N3L) with nonlinear transient structural analysis (Nastran NLTRAN or In-house beam code SNAKE).
- It also implements the dynamic stall model developed by Øye.

- This approach is expected to capture the Limit Cycle Oscillation (LCO) dependent on the geometric nonlinear structure associated with stall.
- The framework is called N3L-Snake.



4 – Transient NL FSI for LCO

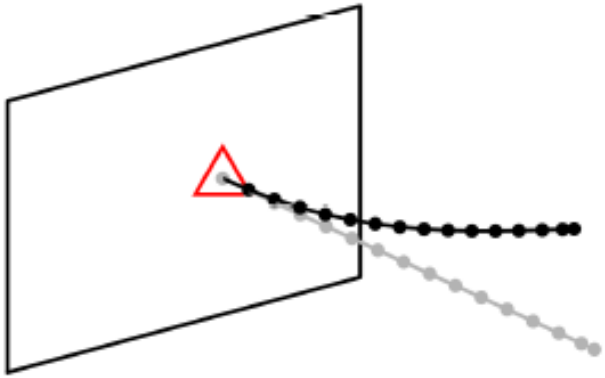


Fig. 1. Transient NL beam model

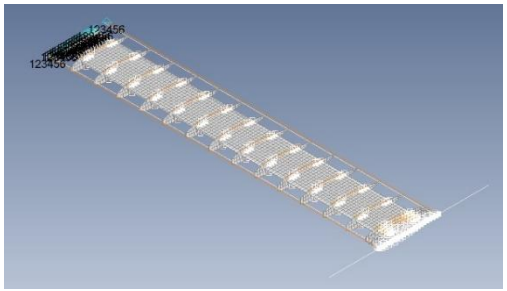


Fig. 2. FEM solve with Nastran NLTRAN

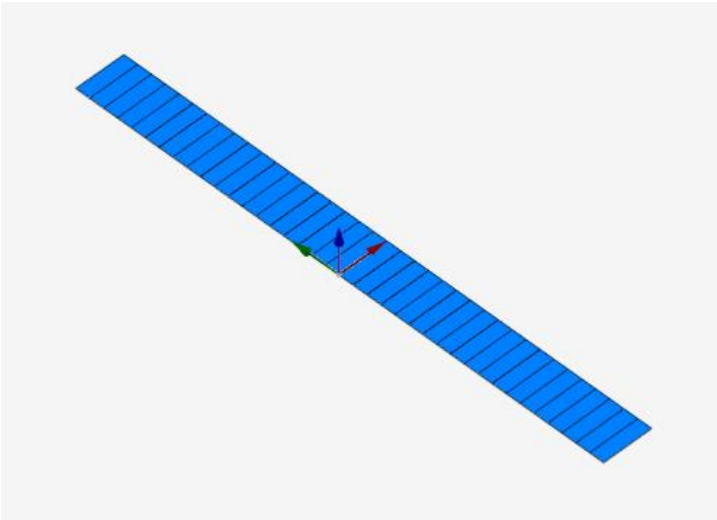


Fig. 3. Aerodynamic model (both sides) in N3L.
Runs a UVLM corrected with XFOIL.

4 – Transient NL FSI for LCO

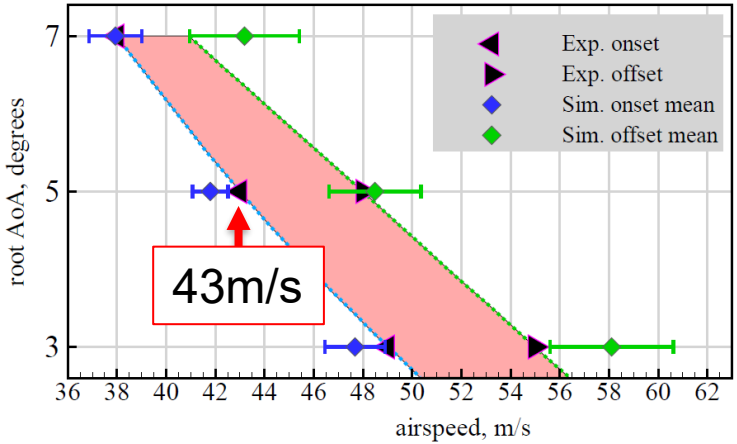


Fig. 1 - Rittter et. al 2024

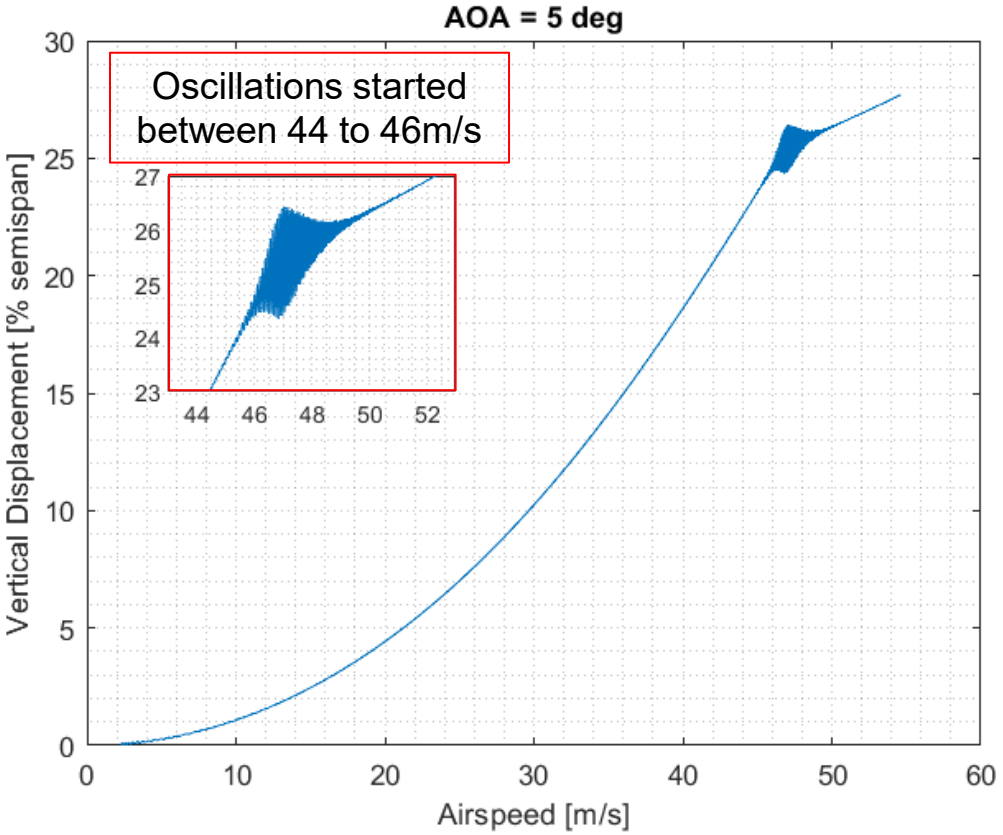


Fig. 2 – Preliminary results N3L-SNAKE, step 0.02s

Conclusion

Structured initiatives are currently in progress by the ITA-Embraer working team in preparation for AEPW-4 and DPW-8.

1. Satisfactory results were obtained with fast loads prediction method, and more information is available on event DINAME 2025 (Almeida et. al 2025).

2. Promising results are being obtained for CRM transonic static deflection with SU2-Nastran coupling.

3. We are eminent to capture the effect of large deflection on aileron balancing using a matched flutter solution.

4. Promising results are being obtained for LCO using N3L-SNAKE framework.

Thank you !

References

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