

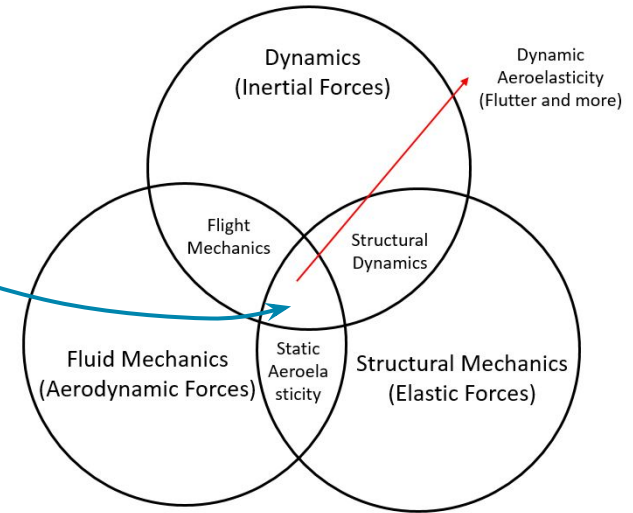
# Multidisciplinary Design Optimization of a semi-aeroelastic hinged wing with respect to flutter criteria

- Tutor : Joseph Morlier



# THE FLUTTER PROBLEM

**Instability** which involves two or more modes of vibration and arises from an **unfavourable coupling**



## Reference:

Wright, Jan Robert, and Jonathan Edward Cooper. *Introduction to aircraft aeroelasticity and loads*. Vol. 20. John Wiley & Sons, 2008.

## Revolutionising Aircraft Wing Design



- Reduce the load transmitted to the fuselage
- Reduce drag
- Combat the effects of turbulence

### Reference:

Castrichini, A., Wilson, T., Saltari, F., Mastroddi, F., Viceconti, N., & Cooper, J. E. (2019). Aeroelastics Flight Dynamics Coupling Effects of the Semi-Aeroelastic Hinge Device. *Journal of Aircraft*, 1-9.

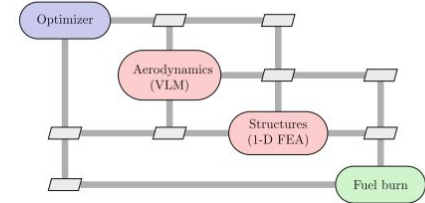
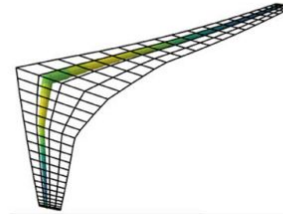
Which is the optimal design for reducing flutter phenomena?



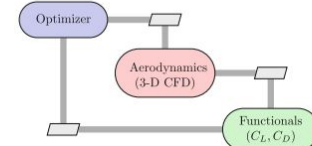
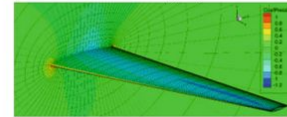


- Python-based, open source framework for coupling multiple models and optimization
- Provides a common platform for the development of new multidisciplinary analysis and design methods

Low-fidelity wing aerostructural opt.



RANS-based wing optimization

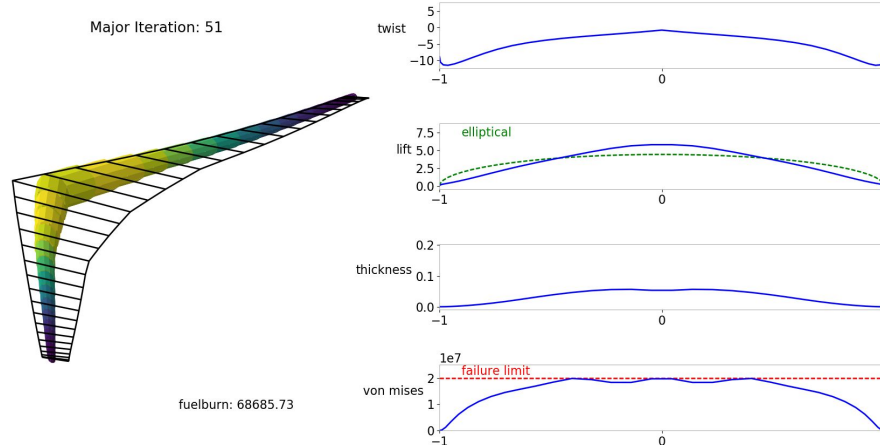
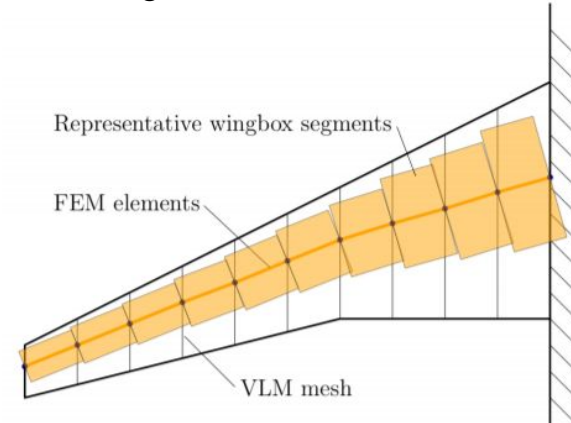


## Reference:

J. S. Gray, J. T. Hwang, J. R. R. A. Martins, K. T. Moore, and B. A. Naylor, "OpenMDAO: An Open-Source Framework for Multidisciplinary Design, Analysis, and Optimization," Structural and Multidisciplinary Optimization, 2019.

- Lightweight tool that performs **aerostructural optimization**
- Couples **VLM** + **FEM** using Python
- Gradient-based optimization with the **OpenMDAO** framework

Wingbox model extension:

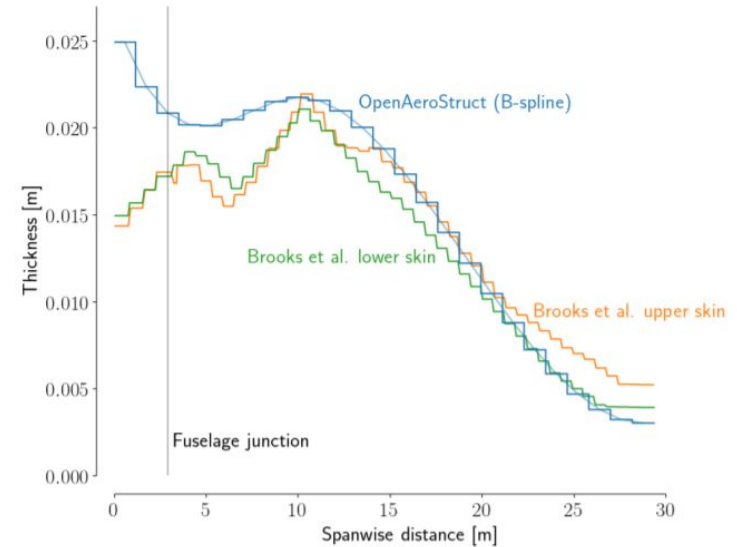


## Challenge

Adapt the OpenAeroStruct code in order to model a semi-aeroelastic hinge

**Objective:** fuel minimization

Method	Wingbox mass	Fuel burn	Time
RANS CFD + FEM with shell elements	23.840 kg	94.037 kg	2 days (1000 processors)
<b>OpenAeroStruct</b> (VLM + FEM with spatial beam elements)	21.468 kg <b>(-10%)</b>	96.239 kg <b>(+2.3%)</b>	2 hours (laptop)



## Reference:

Chauhan, S. S., & Martins, J. R. (2018, September). Low-fidelity aerostructural optimization of aircraft wings with a simplified wingbox model using OpenAeroStruct. In *International Conference on Engineering Optimization* (pp. 418-431). Springer, Cham.

- It is interesting to analyze this revolutionary design
- It is hope to obtain useful pre-design values

## Future works:

- More detailed optimizations with high-fidelity models would offer more accurate results
- Inclusion of flutter control optimization





# Thank you!

