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| ISAE SUPAERO Institut Supérieur de l'Aéronautique et de l'Espace | PhD at ISAE-SUPAERO/DCAS – 3 years<br>Department of Aircraft Design and Operation<br>Electrical Aircraft Dynamics and Design | October 2023 |

# Codesign and Flight Control Laws of flexible aircraft with multiple actuators (distributed propulsion and fractional control surfaces) – Application to lateral flight control law, and load alleviation on high aspect ratio wing.

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## Keywords

Aeroelasticity, Co-design, Flight controls laws

## Profile and skills required

The candidates should have basic knowledge about aerodynamics and flight mechanics, and some expertise or research experience on sizing and optimization of embedded mechatronic and actuation systems. Their safety assessment, certification (processes, regulation, means of compliance) would be an advantage.

## Project description

The next generation of aircraft will be electrically propelled and powered by hydrogen. All the projects

This will require also high Aspect Ratio wings. But high AR aircraft with flexible wings face problems related to the integration of these components and systems such as control surfaces and engines on the wing.

The concept of splitting and distributing control surfaces and related actuation system/components on the wing, in the same way as for the distributed propulsion can offer many advantages but requires more complex control law dealing with optimal allocation.

The design of such systems requires also to address the design of the control law at the same times as the mechanical design. The size, the number of control surface, etc. should be part of the codesign

of the control systems. Comparing to the design done in [1, 2], here we have also to consider the flexibility of the wing during the flight but also on ground. This could be modelized as a multi body systems as defined by [5].

The objective of this project is first to provide a modeling of a flexible high aspect ratio wing equipped with distributed propulsion and fractional control surfaces (ailerons and spoilers).

Then, based on this modeling to do a codesign of the wing, the fractional control surfaces and the distributed engines in order to optimize the lateral control of the A/C, improving roll control on ground and in flight, while also controlling the load on the flexible wing.

The safety and certification analysis for the concept of splitting and distributing control surfaces could be a part of the study, for which one of the objectives is the architecture(s) and the integration principles for this concept in a design-to-safety or design-to-be-certified approach.

## Methodology

- Aeroelastic modeling of a wing considering the splitting of control surfaces and distributed propulsion, using the frame of multibody modeling.
- Co design methodology of the actuators, control surfaces and engines.
- Realization of a demonstrator on bench and wind tunnel of a flexible wing
- Study of the optimal allocation for flight combined with a function of control of lightening the loads of the wing (MLA, GLA).

## References

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[5] Yoann Le Lamer - Modèles aéro-structuraux à haute-fidélité pour la conception d'avions à voilure à grand allongement - Thèse de doctorat ISAE-SUPAERO en cours, 2020-2023.

## Supervision

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For application: send CV, letter of motivation, letter of recommendation, Master grade transcripts …