International Research Training Group IRTG 2657
Computational Mechanics Techniques in High Dimensions

Local/Global Non-Intrusive Strategy for Robust Design

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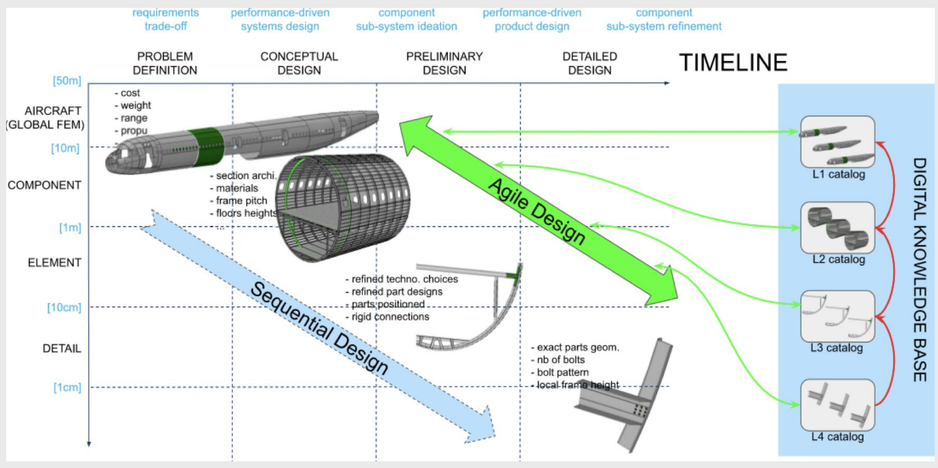
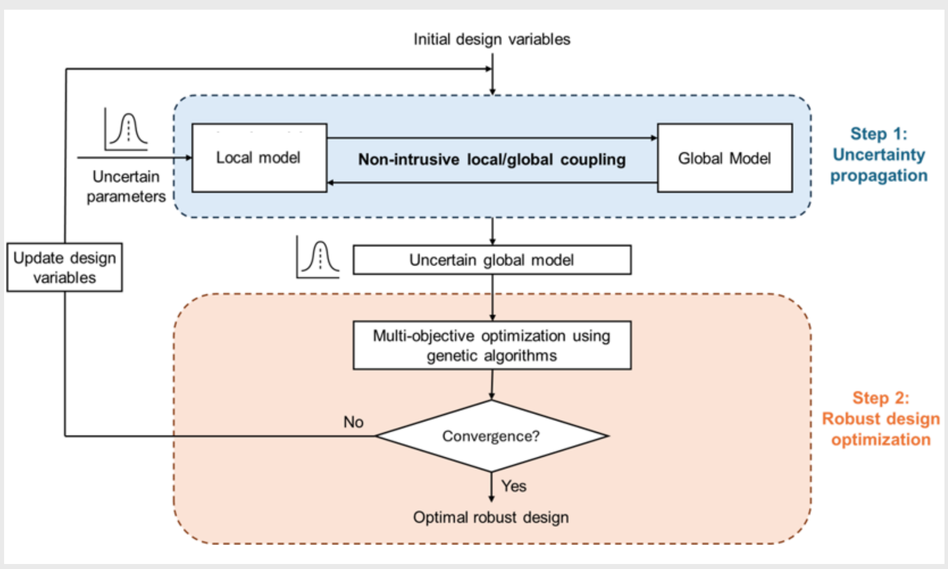
Second Cohort – Starting Date: 01.09.2024

Motivation

Because of operational constraints, **design changes may appear locally** and may lead to late and costly overall design questioning.
The research project aims at taking into account, in the preliminary structural design stages, **the impact of uncertainties of structural details on the global architecture.**



Methods



We propose to extend and couple two families of methods:

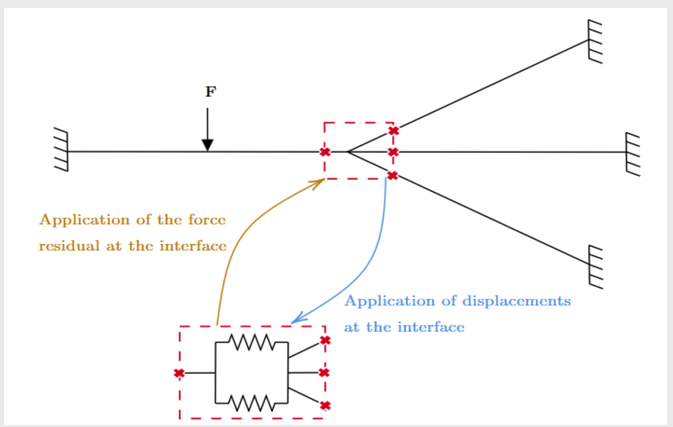
- **non-intrusive local/global methods;**
- **uncertainties propagation methods** (such as Monte-Carlo, perturbation method, polynomial chaos expansion (PCE)…)

Key challenge: Accurate propagation of uncertainties across different scales to ensure reliable performance predictions.

Results

Presentation

Because of assembly constraints, the new structure brings additional flexibility compared to the nominal design.



Robust design formulation

It consists in finding the beam section that minimizes the discrepancy in stiffness despite positional variabilities in the joint which are thus stochastic parameters.

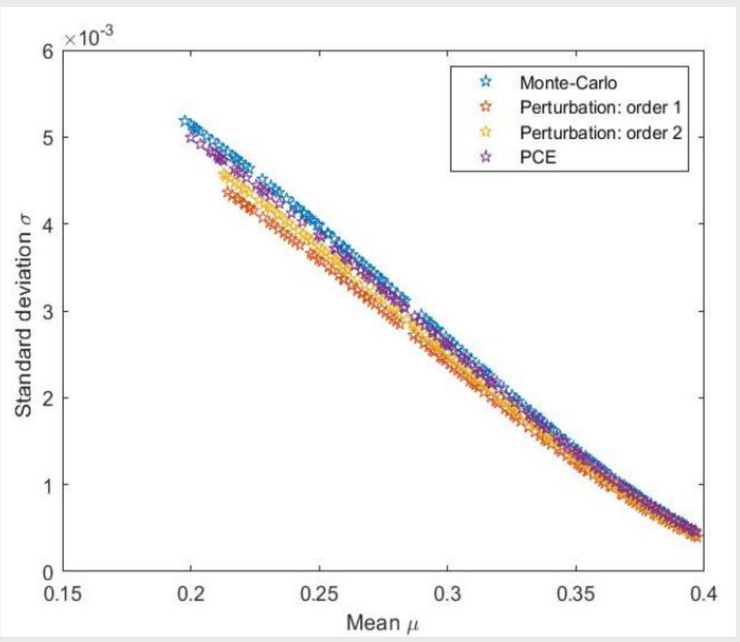
$$Minimize: \mu[F_1(h)], \sigma[F_1(h)]$$

$$Subject\ to\ the\ constraints: 40 \leq h \leq 100mm, \max(\boldsymbol{\sigma}_{VM}) < \frac{R_e}{\gamma}\ in\ the\ joint$$

$$with:$$

$$F_1(h) = \frac{1}{2}\left(\frac{U_F(h, x_1, x_2) - U_F(h_{nom}, x_1, x_2)}{U_F(h_{nom}, x_1, x_2)}\right)^2$$

Robust solutions



The Pareto front is the set of robust solutions, where no objective can be improved without worsening another.

Next Steps

- Extend to 2D and complex cases
- Assess numerical strategies for robust design
- Integrate metamodeling at the global scale for faster exploration

Publications

[1] **L. Karaouni**, L. Chamoin, O. Allix, S. Guinard, Approches local/global non-intrusives et optimisation robuste, 26ème Congrès Français Mécanique 2025, Aug. 2025, Metz, France
[2] **L. Karaouni**, L. Chamoin, O. Allix, S. Guinard, Local/global non-intrusive coupling strategy for robust design: a first attempt, Advanced Modeling and Simulation in Engineering Sciences, 2025

Research Environment

- Participation in Conferences and Workshops
  - CSMA Junior 2025 (Toulouse, France)
  - CFM 2025 (Metz, France)

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