Aircraft Wing Design & Optimization


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Problem Description

In this project, the team will design and optimize wings for various aircraft configurations using a combination of aerodynamic and structural analysis tools. The team will build a workflow that integrates CAD, low- and high-fidelity aerodynamic modeling, and basic structural analysis to explore how engineers approach real-world aerodynamic optimization.

Project Objectives

Utilize refined optimization process and toolset to perform a constrained optimization of the wing planform definition and airfoil parameters of the air vehicle.

Optimization Problem Formulation:

- Objective → Maximize cruise range (specific range parameter of V/SFC * L/D)
- Constraint → Landing approach speed req. (1.2*Vstall) < 120 knots
- Constraint → Wing thickness to span
- Constraint → -5% < Static Margin < 5%

Goal:

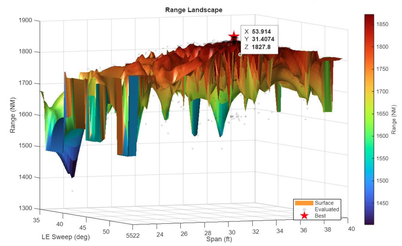
- Formulate a set of design variables and optimize them to meet all constraints while simultaneously maximizing the design objective.

Solution:

- A multi-fidelity workflow to design a transonic aircraft wing. Uses low-fidelity 2D models to rapidly explore thousands of potential airfoil shapes, before passing the most promising designs to a higher-fidelity 3D aerodynamic solver.

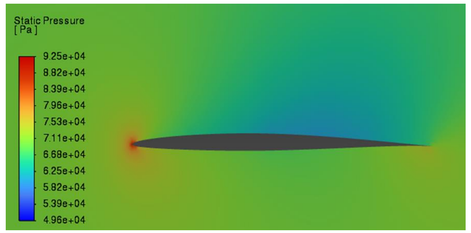
Results Discussion

Low-Fidelity

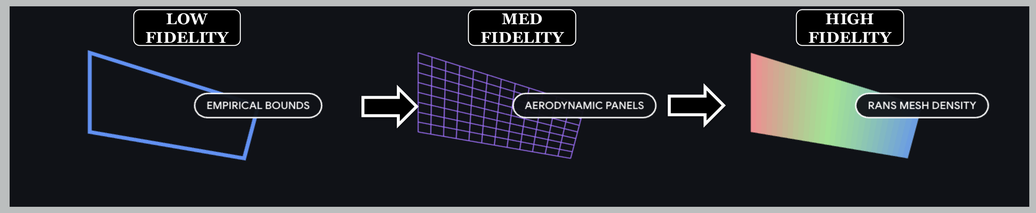


MATLAB genetic algorithm optimization landscape across leading-edge sweep and span. The red star denotes the best design candidate with a range of 1827.8 NM, which is then selected for high-fidelity CFD validation

High-Fidelity



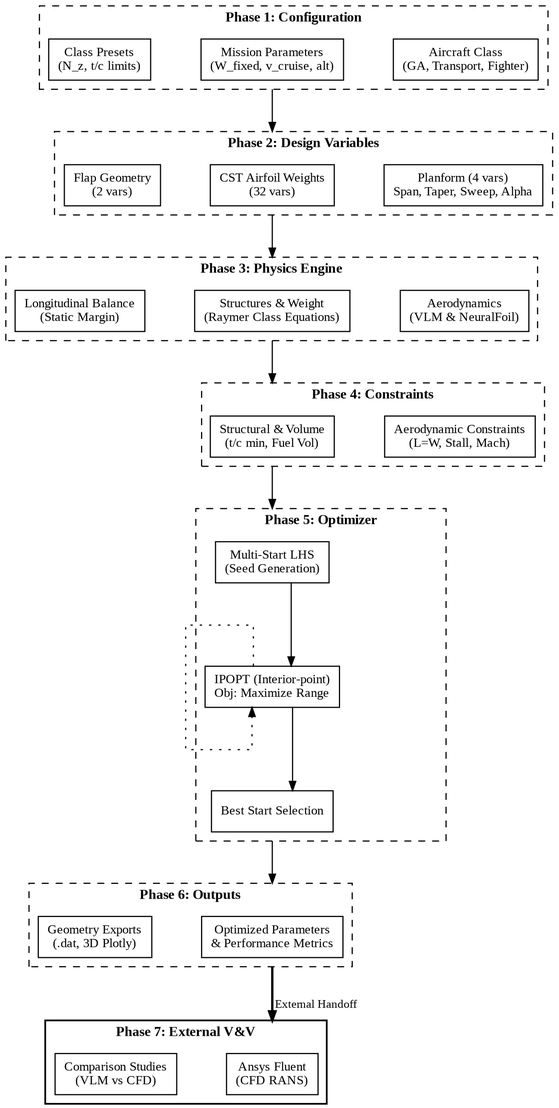
At a flight condition of Mach 0.8 and 10,000 ft AGL with a 3-degree angle of attack, CFD analysis of the optimized XQ-58A Valkyrie wing geometry yielded a Cd of 0.0032, Cl of 0.0701, and L/D of 21.9. These values are consistent with expected delta wing performance at transonic cruise.



Next Steps

Future work will expand validation across additional wing planforms – including tapered, gull, and elliptical geometries – each selected to probe distinct aerodynamic regimes such as induced drag minimization and dihedral stability effects. Concurrently, wind tunnel testing with scale models will serve as experimental ground truth to cross-validate CFD predictions. Once simulation and experimental results converge, the optimization workflow will be integrated into a parametric aircraft design pipeline, enabling rapid, mission-specific wing selection for UAV and advanced air vehicle applications.

Workflow Outline



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