Propeller-Driven Vibration Testing for the Structural Health Monitoring of Multi-Material Wing Structures

PhD proposal • Department of Aerospace Engineering
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Motivation. The pursuit of aerodynamic efficiency and mass reduction has shifted the design of lifting surfaces, such as wings and wind turbine blades, towards high-aspect-ratio structures made of high-specific-strength materials, typically fibre-reinforced composites [1]. In multi-material structures, damage develops through several mechanisms and at different material scales, including fatigue, ductile or brittle fracture and debonding [2]. This complexity makes the source and type of failure difficult to identify by standard visual inspection [3], while **the lightweight wings of propeller-driven aircraft require monitoring during operation.**

Objective and approach. This PhD develops **propeller-driven vibration testing (PVT)** [4], which uses the installed propeller as the sole excitation source, for the health monitoring of these wings. **Closed-loop propeller excitation and automated modal identification** are applied to a multi-material wing **on the ground and in the wind tunnel**. The identified modal parameters are then combined with a **higher-order digital twin to locate and quantify damage**, so that damage tolerance is verified in operation and maintenance is scheduled on condition.

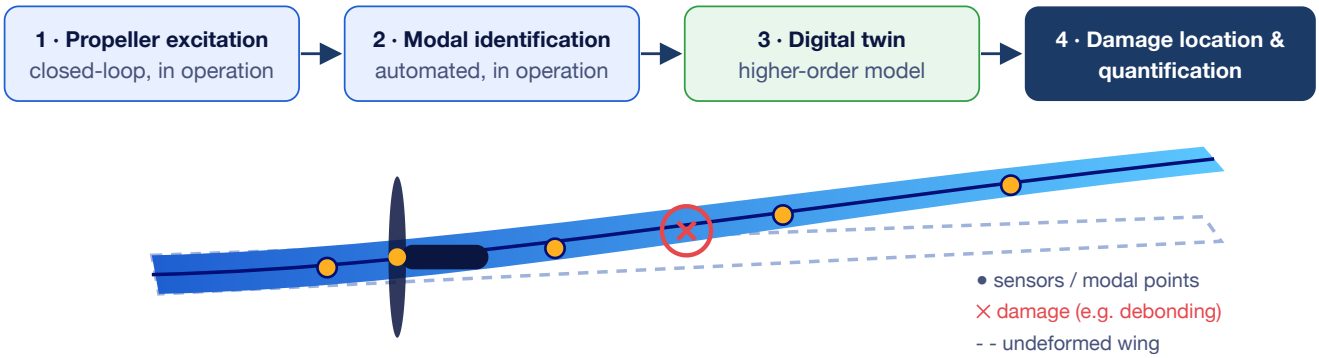


Figure 1: Research concept. The installed propeller excites the wing; modal parameters identified automatically on the ground and in the wind tunnel update a higher-order digital twin that locates and quantifies damage.

Expected outcomes. An in-operation vibration-testing methodology that needs no external exciters for propeller-driven aircraft; automated modal-identification pipelines robust to operational conditions; and a digital-twin-based damage localisation and quantification framework, validated experimentally on a multi-material wing, enabling condition-based maintenance.

Keywords. Structural health monitoring · propeller-driven vibration testing · digital twin · damage localisation · wind tunnel

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