Project Title - Multidisciplinary Design Optimization for Hypersonic UAVs

Host University - University of Canterbury

Industrial Partner - Dawn Aerospace

Academic Supervisor(s)

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Project Description

Dawn Aerospace is developing a remotely operated rocket powered reusable spaceplane with applications in both the commercial space transportation and defence and security domains. Dawn Aerospace sees hypersonic capabilities (Mach > 5) as the next logical step in the further development of high-performance UAVs.

Hypersonic flight vehicles experience extreme thermal and aerodynamic (aerothermal) environments that are strongly coupled to vehicle shape. Current approaches to hypersonic vehicle design are primarily constrained by the high computational cost and limited integration capability of conventional computational fluid dynamics (CFD) tools. Accurately resolving the complex hypersonic flow features is prohibitively time intensive. As a result, iterating on vehicle geometry becomes a slow and (computationally) expensive process, often restricting designers in their exploration of the design space. Consequently, there is a critical need for a novel rapid design methodology that can accelerate shape optimization while retaining sufficient physical accuracy, allowing efficient integration into next generation vehicle design pipelines.

The primary aim of this doctoral project is to develop a rapid, physics-informed design framework to optimize the shape of a next-generation reusable hypersonic vehicle. The tool shall be capable of evaluating large numbers of candidate geometries, combining reduced-order aerothermal models with modern optimization strategies to efficiently identify preliminary design configurations. Crucially, the predictive capability of the fast tool must be validated against high-fidelity reference data either from computational fluid dynamics (CFD) simulations and / or wind-tunnel experiments. Where available, flight data from the actual Mk-II B vehicle will serve as the ultimate validation benchmark. The method will bridge the gap between high-fidelity analysis and practical vehicle design accelerating of the development of a new generation of hypersonic vehicles, enabling more efficient space access, unique defence capability, advanced atmospheric flight missions, and improved reusability.

Research Objectives

• Develop and apply a rapid, physics-informed design framework to optimize the shape of a next generation hypersonic vehicle.

• Combine reduced-order aerodynamic and aerothermal models with modern optimization strategies.

• Investigate surrogate modelling, parametric geometry descriptions, and automated optimization methods to allow the system to evaluate large numbers of candidate geometries while enforcing constraints on heating, stability, lift-to-drag ratio, and structural feasibility.

Student Time Split

University base for student (university, campus, department):

University of Canterbury, Mechanical Engineering

Industry base for student (company, site, address):

Dawn Aerospace (Middleton Drive, Christchurch)

Expected Time Split Between University and Industry Partner (in months):

Time with Industrial Partner (months): 24 months // Time with Academic Partner (months): 12 months.

Rationale for Time Split:

This project involves both theory and hands-on engineering. Dawn Aerospace already has extensive hardware, test capabilities, and leaders with strong field knowledge to support the student in validating the project findings. Leveraging UC's theory strength and analysis / validation capabilities is expected to be useful for the more generalized aspects.

We expect the project to begin with a primary start at UC, becoming more involved at Dawn's workplace, before giving the student space to write up their results at the end wherever suits them best.

The close proximity of Dawn to the University of Canterbury (<10 minutes drive) allows for seamless access to both locations, with no relocation or transportation costs for the students. It also allows for a close relationship between the Industry partner supervisor(s) and academic supervisors.

Application

To apply for this project please first read the guidance document and then complete the application form on the Applied Doctorates Scheme website.