The role of numerical methods within the modern design process: An application to hydrogen injection system development for aero-engines

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The modern design process needs to be rapid. Project lifespans are relatively short (2-5 years) and demand a rapid increase in technology development. Funders want tangible results: prototypes and demonstrators. In order for new technologies to skip over the valley of death, they need to meet these strict requirements and so new ideas, shared on paper, need to become products in a fast and efficient manner.

Numerical simulation is one of the more powerful tools available to the designer. Simulations allow the user to probe the design space, reducing the number of tests required and reducing the risk of failure during testing. Many different types of numerical simulations and tools are available. This talk will show how numerical simulations of many different levels of fidelity can be used to help accelerate the design process applied to the development of novel hydrogen injection systems for aircraft engines.

These methods will include automated workflows for the design of experiments and collection of statistics [1], adjoint shape optimization, RANS and LES simulations, and the building of surrogate models and digital twins [2]. Experimental results will also be shown to highlight the trade-off between cost and accuracy of each method and how each method can be used optimally at each stage of the design process.

[1] Treleaven, NCW et al. Optimization of a Hydrogen-Fueled Parametric Strut Injector Using an Automated Workflow Computational Fluid Dynamics Method. Journal of Engineering for Gas Turbines and Power, 2025;147(3).
[2] Deshons et al. “Application of Digital Twin Technology to Aeronautical Combustion: A Case Study on Hydrogen Microinjectors” in Turbo Expo: Power for Land, Sea, and Air. (American Society of Mechanical Engineers, 2025) GT2025-153184.