AEROSPACE ENGINEERING

MUR DM 117/CIRA - Aerodynamic analysis and optimization of super/hypersonic aircraft

Funded By	CIRA S.c.p.A. [P.iva/CF:01908170614] MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Politecnico di TORINO [P.iva/CF:00518460019]

Supervisor	D'AMBROSIO DOMENIC - domenic.dambrosio@polito.it

Contact	Roncioni Pietro - CIRA Schettino Antonio - CIRA D'AMBROSIO DOMENIC - domenic.dambrosio@polito.it

Context of the research activity	This Ph.D. project aims to develop a digital aerodynamic design tool for future hypersonic aircraft that will combine Computational Fluid Dynamics (CFD) with reduced-order models for efficient aerodynamic analysis. The simulation tool will employ optimization techniques to shape the vehicle according to requirements within the diverse flight regimes encompassing the flight envelope of a hypersonic aircraft. Progetto finanziato nell'ambito del PNRR – DM 117/2023 - CUP E14D23001970004

	The overall design of an aircraft capable of super/hypersonic speeds is closely related to its aerodynamic design. The limited experience with aircraft currently operating in this regime, the significant effect of shock waves on drag, the management of high thermal loads, and the integration with the propulsion system present a design challenge that requires advanced numerical simulation systems. Computational Fluid Dynamics (CFD) is the most accurate tool for obtaining detailed design information, especially when it is validated, at least partially, with experimental data. However, in the early stages of a project, it is more efficient to use tools based on reduced-order models. At these stages, it is crucial to quickly provide the designer with a complete aerodynamic and aerothermodynamic database using computational tools that are less accurate but faster than CFD. Therefore, being able to perform aerodynamic analyses with different levels of approximation and manage the uncertainty associated with the results at each stage of the design is critical. However, using accurate CFD tools remains essential because, combined with experimental data, it helps to control uncertainty.

Objectives	The operating conditions of a hypersonic aircraft are not limited to high Mach number flight. The low supersonic, transonic, and subsonic regimes are part of the set of flight conditions and generally require reduced-order models different from those used in the hypersonic regime. Therefore, it is necessary to have an aerodynamic analysis and design tool that integrates reduced-order models for the diverse flight regimes and can be easily interfaced with CFD codes to evaluate uncertainties. During the different phases of the project, the generated databases can be used to optimize the aircraft shape using deterministic or robust optimization techniques, depending on the available resources and requirements. The ultimate goal of the Ph.D. project is to create a digital design tool that integrates the different models involved in the aerodynamic design of a hypersonic aircraft and can easily interface with digital optimization tools. This tool will allow designers to perform detailed aerodynamic analyses, manage the uncertainty associated with the results, and optimize the shape of the aircraft according to specific requirements. The Ph.D. candidate will develop and implement reduced-order methods in hypersonic aerodynamics or improve existing ones, and he will also consider reduced-order approaches for transonic and subsonic aerodynamics. He will integrate the diverse reduced-oder method in a comprehensive simulation tool that he will interface with existing optimization tools. He will also conduct accurate CFD simulations on hypersonic vehicle configurations using existing CFD software to check the accuracy of reduced-order methods and define their inherent uncertainty.

Skills and competencies for the development of the activity	We are looking for candidates who exhibit strong analytical skills, autonomy, and initiative. Applicants should possess knowledge of supersonic aerodynamics and computational fluid dynamics, typically obtained through a Master's degree in aerospace engineering. Additionally, familiarity with programming languages, coding, and information is desirable. Prior experience in hypersonic aerodynamics would be advantageous.