POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

PNRR 118 PNRR Research Field: INTERACTIONAL AERODYNAMICS OF ADVANCED ELECTRICAL VERTICAL TAKE-OFF AND LANDING AIRCRAFT (EVTOL) FOR SUSTAINABLE AIR MOBILITY

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The concept of new personal short-range VTOL vehicles characterised by electrical propulsion (eVTOLs) has become a compelling alternative to ground traffic in increasingly overcrowded metropolitan areas and a promising solution for sustainable air mobility. These vehicles, characterised by multi-rotor and multi-wing configurations, present unprecedented aerodynamic challenges due to the occurrence of several different interactional effects usually absent in standard aircraft architectures. These interaction mechanisms profoundly impact the aerodynamic performances of the aircraft as well as the noise generated, so their investigation is of utmost importance to fully understand the complex environment characterising eVTOL vehicles. Such a knowledge advancement and the availability of accurate tools for simulating the different stages characterising the flight mission of these aircraft are essential to improve their design and to make these vehicles a reality for next-generation sustainable air mobility and a pivotal contribution to sustainable transport, one of the key topics related to SDG11. To answer this demand, the present research programme heads towards establishing a systematic ground-breaking synergy among simulations and experiments. The experimental and numerical investigation activities are combined seamlessly from a global perspective. In particular, the project is aimed to drive the construction of an open-access comprehensive

	database, marking a new reference for eVTOL applications. Namely, the project involves a series of aerodynamic wind tunnel tests targeting multiple wings/rotors configurations. State-of-the-art measurement techniques such as Particle Image Velocimetry, unsteady pressure measurements and Infrared Thermography are planned to be used to increase the description of the interactional mechanisms typical of eVTOL architectures. The experimental database will be enriched by numerical predictions obtained from computational models of increasing fidelity. The proposed multi-fidelity approach flows naturally into the delivery of an enhanced low-order model for simulating the aerodynamics of such complex configurations. Thanks to the introduction of ad-hoc correction functionals, the validity of low-order predictions will be extended to the whole flight envelope, including deeply stalled conditions. The ultimate goal is to provide an accurate, computationally cheap, open-source simulation tool to be used for a multi-disciplinary optimisation of unconventional configurations of the next-generation eVTOL vehicles. The effectiveness of the developed framework will be demonstrated on an industrial test case consisting of a wing equipped with multi-propellers targeting the optimization of the aerodynamic performance. Noise emission of the multi-rotor configuration will be also verified by means of an experimental campaign in an anechoic wind tunnel.
Methods and techniques that will be developed and used to carry out the research	A period of 6 months, not necessarily continuous, will be spent in collaboration with the German Aerospace Center (*DLR*), Institute of Aerodynamics and Flow Technology, in the form of an internship.
Educational objectives	The specific objective of this PhD is to develop skills in experimental and numerical aerodynamics. Through this project, the candidates will develop skills not only in mathematical modelling, numerical analysis and experiments but also an attitude open to innovation and exchange between the research and industrial worlds, with a general focus on the preservation of the ecosystem, biodiversity, reduction of the impact of climate change through technological innovation and promotion of

	sustainable development. In this sense, education will be complemented by a broad variety of soft skills, including presentation of the research, report writing, outreach, dissemination, and preparation of industrial progress meetings.
Job opportunities	The job opportunities that this project opens up are in the field of aerodynamics and aeroacoustics. The research is framed in the context of PNRR.
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 0 PhD Students
Name of the research directors	Alex Zanotti

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	
By number of months at the company	0
Institution or company where the candidate will spend the period abroad (name and brief description)	DLR (DE)
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
The PhD candidate will receive a desk, possibly through a hot-desking procedure, and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses and receive economic support to attend summer schools and participate in conferences. There will be the possibility of paid teaching assistantship.


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