POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 37th cycle

THEMATIC Research Field: INNOVATIVE HUMAN-MACHINE INTERFACES FOR FUTURE PERSONAL AIR VEHICLES

Monthly net income of PhDscholarship (max 36 months)
€ 1325.0 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 research aims to develop criteria for defining, designing and verifying the functionality and acceptability of human-machine interfaces for the management of advanced air mobility (AAM) personal air vehicles (PAV). PAVs represent an extremely promising solution to problems of significant social interest such as congestion in urban areas, travel times, and, indirectly, pollution related to transportation, in complementarity with other shared and on-demand means. These themes, characteristic of the Aerospace area (section 5.3.2 of "Strategia Nazionale di Specializzazione Intelligente"), present specific synergies with the areas • Smart factory ("Fabbrica intelligente"): the aerospace sector has industrial products as its natural outlet; • Sustainable mobility ("Mobilita¿ sostenibile"): a development perspective of the helicopter sector includes individual mobility; • "Smart, Secure and Inclusive Communities": by virtue of more complete integration of transport systems, thus improving the quality of life. The technological development, certifiability, and social acceptability of these aircraft requires bridging numerous gaps: distributed electric propulsion, high energy density

	accumulators, integrated fast charging systems, automation levels well above the current ones, integration with centralized and distributed systems of air traffic management. Among these, usability by non-specialized users is important. The technologies and operational capabilities required overlap with those of emergency and rescue rotorcraft, which may benefit as well from the proposed research. The proposed research is highly innovative in the development of human-machine interfaces for the management of vehicles, in particular aircraft, and in the qualitative and quantitative evaluation of their effectiveness, versatility, and robustness to adverse interactions with vehicle dynamics.
Methods and techniques that will be developed and used to carry out the research	The conception, prototyping, and evaluation of innovative means and devices to control the vehicles is the focus of the research. Fast prototyping techniques will be used, available from DAER and the partner company, LHD. The required software will be developed in DAER's FRAME-Sim flight simulation laboratory. The functionality will be evaluated in the FRAME-Sim lab, in the joint POLIMI-LHD laboratory, PICHASSO, for the biomechanical characterization of pilots, and at ZAV. It will focus on subjective assessments and objective measurements during simulator tests by test pilots and professional pilots, according to protocols to be defined during the research in accordance with aeronautical regulations. The study involves the prototyping and evaluation of innovative solutions and architectures with respect to the state of the art, with unconventional mechanisms of interaction between the pilot/operator and the aircraft, for which a patent is expected. The need to evaluate the physical and psychological commitment of the pilot in objective as well as subjective

	ways also opens up the possibility of developing and testing innovative technologies. The integration of these technologies with the aircraft control systems represents a further possible fallout and highlights the multidisciplinary nature of the project. The research group is multidisciplinary: to the purely aeronautical skills, in the specific field of rotary-wing aircraft, also design and biomechanics competencies are available, thanks to the support of colleagues from the respective departments. The availability of the FRAME-Sim flight simulation laboratory is a key asset for the research. The DAER, in collaboration with industrial and academic partners, has adequate equipment for the prototyping of the devices that are planned to be developed and for the execution of all the necessary tests. Given the high degree of innovation compared to conventional systems, the evaluation of the proposed solutions will take place with the support of eXtended Reality (XR, Virtual / Augmented) techniques, in minimizing the need for the creation of detailed prototypes. The skills in using XR systems are already present in the FRAME-Sim laboratory.
Educational objectives	The candidate will develop specific skills related to the dynamics and aeromechanics of vertical take-off aircraft, human-machine interaction, simulation, virtual reality, biomechanics, ergonomics, and systems integration. In addition, by working in a mixed and vibrant academic and industrial context, the candidate will have the opportunity to learn on the job several transferable skills, including communication skills, team working, leadership, ethical aspects associated with the use of innovative technologies. In support of this, the Ph.D. School of Politecnico di Milano provides a complete and rather diverse offer of courses. At the same time, each candidate must include at least 10 ECTS in transferable skills in their study plan, to complement at least another 5 ECTS in

	technical disciplines associated with Aerospace Engineering, to form a total of at least 20 ECTS.
Job opportunities	The research addresses a central topic, the aircraft-pilot interface, within a class of very innovative aircraft characterized by very promising developments. These aircraft, characterized by vertical/short take-off and landing needs, are placed in the low-end segment of the rotary-wing aircraft family, in which the national industry has played a leading role in the world for years. This industry, which has long been committed to filling the segment of high-range / speed aircraft through the technology of the tiltrotor, has recently begun to move to cover the low but equally promising segment, which in addition to PAVs also includes aircraft with optional and remote piloting (OPV, RPV). The opportunity to cover these areas is highlighted by numerous studies, both nationally and internationally, including the ¿Strategia Nazionale di Specializzazione Intelligente 2014-2020¿ (section 5.3.2 Aerospace), and will be incorporated in the next Piano Nazionale della Ricerca (PNR 2022-2027). Therefore, the candidates find natural application in the national, European, and worldwide aerospace industry in a sector that promises strong expansion and therefore requires strong competitiveness to maintain the top-level role that the national industry currently occupies. However, they also find application in numerous other high-tech industrial fields, in which the human-machine interface, simulation, virtual reality, automation, ergonomics, biomechanics, and the integration of complex systems play a fundamental role, ranging from industrial automation to biomedical applications, from design to the video game industry, just to name a few.
Composition of the research group	2 Full Professors 0 Associated Professors 2 Assistant Professors 4 PhD Students
Name of the research directors	Pierangelo Masarati

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	566.36 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

The Ph.D. candidate will receive a desk, a personal computer. Apart from the compulsory ones, the Ph.D. candidate will have the opportunity to follow additional courses, receive economic support to attend summer schools, and participate in conferences. There will be the possibility of paid teaching assistantship.