



PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 38th cycle

**PNRR_352 Research Field: ADVANCED GUIDANCE, NAVIGATION AND CONTROL FOR
FULLY ACTUATED DRONES**

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

Funded by PNRR M4C2 (dalla ricerca all'impresa)
Contributes to M1C2 (digitalizzazione, innovazione e
competitività nel sistema produttivo)

Since the beginning of the use of drones for civil
applications their potential for environmental monitoring
and agriculture has been evident: drones can reach
otherwise inaccessible locations (e.g., mountains or
forests where access from the ground is hard or
impossible) and can assist in collecting a wide range of
data (e.g., weather, soil moisture, and health of crops and
vegetation)

All the above-described applications would benefit from
the availability of drone platforms capable of high
maneuverability (e.g., to operate in strong winds or to
withstand turbulence) and/or capable of collecting
measurements in contact with the object to be measured.
Such performance cannot be provided by conventional
multirotor platforms but only by fully-actuated ones, which
however pose significant challenges from the point of view
of guidance, navigation, and control, still, partially open in
the literature.

The aim of this project is to define an integrated and
systematic development process for the guidance,
navigation, and control systems of fully-actuated multirotor
drones, to face requirement specifications corresponding
to current needs in civil inspection applications, chiefly
environmental monitoring and agriculture.



	<p>The scope of this project embraces: modelling and identification of the dynamics of fully-actuated multirotors, both in fixed-tilted and tilting configuration; development of detailed simulation tools to support the design, verification, and validation of GNC systems; development of systematic analysis and design methods for such systems; verification in controlled conditions, using the FlyART facility of Politecnico di Milano; in-field validation in representative application scenarios.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The candidate will first develop the skills required to perform the project, building on pre-existing competencies of control theory and control engineering, robot control, drone flight dynamics, and related mathematical methodologies, involving:</p> <ul style="list-style-type: none"> ¿ State-of-the-art design methods for drone systems, including the use of sustainable materials and technologies to maximise the sustainability of the solution throughout its life cycle. ¿ Autonomous navigation, combining GNSS, vision-based, and visual/inertial navigation, with distributed formation-based localisation. ¿ Autonomous guidance: planning and re-planning with constraints for obstacle avoidance, driven by mission and safety objectives. ¿ Joint force/position control with specific reference to the case of aerial vehicles. <p>Verification and validation (V&V) of formation autonomy, a major challenge per se, will be faced using systematic methods for the design of realistic benchmark scenarios. The V&V of the project¿s findings will be carried out as follows:</p> <ul style="list-style-type: none"> ¿ Indoor conditions in the FlyART PoliMI flight arena, to verify the HW/SW characteristics of the platforms and the implementation\tuning of the GNC algorithms. ¿ Indoor harsh conditions, using PoliMI¿s wind tunnel for performance validation in wind and turbulence; ¿ Outdoor campaigns, for conclusive experimental validation in outdoor scenarios related to the coordinated formation exploration of a wild area.



	<p>A 6-month period will be spent in collaboration with an industrial partner. Two 3-month internships under the joint supervision of an academic and an industrial tutor will facilitate a proficuous bidirectional exchange between research and industry, to design the drone platforms and jointly carry out the experimental campaigns for the validation of the designed drone system.</p> <p>The industrial partner of the research will be ANT-X s.r.l. (http://www.antx.it), a spin-off company of the Aerospace Systems and Control Laboratory of the Department of Aerospace Science and Technology of Politecnico di Milano. ANT-X has the competencies needed to carry out the design, prototyping, integration, and flight testing of UAV systems both for scientific research and for industrial applications:</p> <ul style="list-style-type: none"> ¿ Design of drone systems tailored to the specific application, based on the user¿s requirements, using innovative configurations. ¿ Selection and integration of suitable payloads to the user¿s application. The use of state-of-the-art open-source onboard software allows for easy integration with payload and existing infrastructure. ¿ Development of the UAS, including design, integration, and prototyping. ¿ Support in operations, by providing assistance to guarantee compliance with regulations. <p>The proposed research will build on existing cooperation between DAER and ANT-X, which won the Leonardo Drone Contest in 2020.</p>
<p>Educational objectives</p>	<p>The candidate will develop skills in control theory and control engineering, robot control, drone flight dynamics, and in general in all disciplines that characterize the dynamics and control of multicopter drones, with specific reference to fully-actuated ones. 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, and 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. Each</p>



	candidate must include in their syllabus at least 10 ECTS in transferable skills, to complement at least other 5 ECTS in technical disciplines associated with Aerospace Engineering, for a total of at least 20 ECTS.
Job opportunities	The candidate will find natural opportunities in the national, European, and worldwide drone industry in a sector that is currently growing very rapidly. At the national level, strong competitiveness is needed to position the national industry in a top-level role. The candidates may also find opportunities in numerous other high-tech industrial fields, in which competencies in dynamics, control, aeromechanics, and optimization, as well as the experience gathered in the integrated design of complex systems, play a fundamental role, centered on but not limited to industrial engineering.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 5 PhD Students
Name of the research directors	Prof. Marco Lovera

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)	ANT-X s.r.l. (http://www.antx.it), a spin-off company of Politecnico di Milano
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Controls Group for Distributed and Uncertain Systems at the University of Texas, Austin
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 and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses, to receive economic support to attend summer schools and participate in conferences. There will be the possibility of paid teaching assistantship.