POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 38th cycle

PNRR_352 Research Field: MODELING AND SIMULATION OF PLANETARY AEROBRAKING MANEUVERS

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) Aerobraking is a space-flight maneuver through which an orbiting spacecraft brushes against the top of a planetary atmosphere. The friction of the atmosphere against the surface of the spacecraft is used as a fuel-less way to dissipate the spacecraft mechanical energy, and in turn to decrease the semimajor in a sequence of passages, typically prior to science operations. The solar panels as well as a dish antenna are used to provide the maximum drag in a symmetrical position that allows some control as the spacecraft passes through the atmosphere. Following an increased and renown interest toward planetary exploration, performing an aerobraking maneuver is being planned as a baseline solution in interplanetary mission designs. However, the fuel reduction comes at the cost of an increased complexity in system design and operations, e.g., heat fluxes and spurious torque have to be assimilated by the system. Moreover, the uncertainty inherent in atmospheric models requires robust and possibly autonomous execution of the aerobraking maneuver. The objective of this PhD is to develop methods and techniques to simulate the planetary aerobraking maneuvers under the perspective of a system-orbit multidisciplinary modeling, design, and optimization, as

	well as to support the definition of the operational concept during the aerobraking maneuver.
Methods and techniques that will be developed and used to carry out the research	From a methodological point of view, the PhD project will rely on modelling and simulation of the planetary aerobraking maneuver under a coupled system-orbit perspective. The baseline is to adopt the model-based systems engineering (MBSE) paradigm. The multidisciplinary MBSE approach proposed relies on the abstraction of the inherently multi-physics systems typical of the space domain, and is organized in five layers: 1) Definition of mission and system requirements and translation into their digitally handled analogues; 2) Modeling of the multidisciplinary systems from first principles; 3) Implementation of the mathematical and physical models into efficient numerical frameworks, 4) Definition of operative scenarios and execution of the associated simulations; 5) Automated requirement verification and possible system/orbit design iterations. This approach allows performing a multidisciplinary system-orbit optimization, as well as it supports the definition of the concept of operation of the aerobraking maneuver. Attention will be given to assess the feasibility and reliability of autonomous aerobraking maneuvers, which could potentially bring savings in the operation costs too.
Educational objectives	The objective of this PhD is to develop skills in space system modelling and simulation as well as in space flight mechanics. The candidate will gain relevant expertise in space exploration, mostly in planetary exploration. Through this project, the candidates will develop skills in mathematical modeling, numerical analysis, computer programming (Matlab, Python, C++, or similar), and space mission and system design. Moreover, the candidate will develop skills on computer simulations. Soft skills in disseminating the research, writing reports, performing outreach, and preparing industrial progress meetings will be also achieved through the PhD project. These educational objectives will be also acquired through a six-month secondment at a space system integrator company. In addition, the PhD student is

	supposed to spend 6 months in a foreign university/research center/company. The timeframe and location of the secondment at the CubeSat company as well as the period abroad will be defined during the PhD career development plan, to be developed within the first semester after the kick-off of the activity.
Job opportunities	The current research prepares the PhD candidate to both academic and industrial careers. Knowledge of model-based system engineering, modeling and simulation of space systems, as well as space flight mechanics are fundamental skills for careers in space-related companies and universities.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Francesco Topputo

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)	Thales Alenia Space - Italia
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	The PhD student is supposed to spend 6 months in a foreign university/research center/company. The timeframe and location of the secondment as well as the period abroad will be defined during the PhD career development plan, to be developed within the first semester after the kick-off of the activity.

By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
The candidate will be hosted in the DART Lab (Deep-space Astrodynamics Research & Technology Laboratory) at the Department of Aerospace Science and Technology, Politecnico di Milano. During the PhD program, the candidate will have access to the facilities of the DART Lab to carry out experimental activities. The candidate will also have the opportunity to attend some PhD classes on both soft and hard skills. Moreover, there could be the possibility to carry out activities as teaching assistant. The PhD candidate will receive a desk, a personal computer. 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.