POLITECNICO DI MILANO

# PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

## PARTENARIATO PNRR Research Field: RESIDENT SPACE OBJECTS CHARACTERIZATION FOR SPACE SURVEILLANCE AND TRACKING APPLICATIONS

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

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | Space, as a shared domain for humanity, requires the cooperation of both governmental entities and private enterprises to ensure its sustainable utilization. Within this framework, the concept of Space Situational Awareness (SSA) holds significant strategic importance from both commercial and defense standpoints, primarily due to the growing population of objects in space. Within this context, various international Space Surveillance and Tracking (SST) initiatives are devoting efforts to advancing the capability to build a comprehensive map of objects in orbit, categorize them, and predict their orbital trajectories. This effort serves several key purposes, in particular to provide services such as collision avoidance, re-entry monitoring and analysis of on-orbit breakup events. To do that, data are collected through a network of optical, radar and laser ranging sensors; the acquired data are then analyzed and integrated into a centralized database. This research aims at enhancing the quality of SSA services, particularly within the near-Earth vicinity, with a specific focus on the accurate characterization of observing targets. The objective will be achieved through the development of innovative observation strategies and advanced processing algorithms, especially tailored to ground-based optical and radar sensors.<br><br>Borsa parzialmente coperta da fondi PNRR Infrastrutture Croce del Nord (CUP C53C22000880006) e parte da fondi ASI-ISTAR (CUP F43C23000130005) |

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| **Methods and techniques that will be developed and used to carry out the research** | The objective of this research is to improve the state of the art of Resident Space Objects (RSO) characterization, both for cataloged and newly detected cases. Specifically, the candidate will undertake an analysis of light curves generated by an RSO positioned in low Earth orbit (LEO), as observed through either radar or optical sensors. Target's characteristics such as shape, radar cross section, attitude and rotational period will then be determined, with the ultimate goal of providing stronger support to SSA services (e.g., in the identification of collision-prone objects). In the second hand, the developed algorithms will be extended to the observational data related to multiple targets simultaneously detected by a sensor, such as in proximity operations. This involves gaining a deep understanding of relative orbital dynamics and uncertainty quantification. The activity is strictly connected to the target object characterization, as the estimated attitude profiles may represent an added value to proximity operation monitoring. Finally, the candidate will investigate an additional method to improve the characterization of RSOs, particularly regarding radar sensors, which involves the use of a multistatic radar system configuration. In this setup, the system includes multiple spatially distributed monostatic or bistatic radar components with a shared area of coverage. This configuration allows different aspects of a target to be viewed simultaneously, presenting several advantages over conventional systems. Throughout all the activities, the candidate will have the opportunity to exploit Artificial Intelligence (AI) techniques and will validate the efficacy of the developed algorithms using both synthetic and real observations data. |
| **Educational objectives** | This study involves understanding the present status of SSA services and their capabilities. This understanding serves as a foundation for training a skilled professional capable of effective engagement in an international context within this domain. To practically execute this analysis, a comprehensive review of existing literature on strategies and methodologies is necessary, thus leading |

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| | to an improvement of the scientific knowledge of the candidate. This proficiency will enable the researcher to address contemporary space-related challenges, thereby playing a role in the advancement of the space sector. Throughout this process, the candidate will acquire in-depth knowledge spanning astrodynamics, estimation techniques, numerical methods, mathematical modeling, and computer programming (Matlab, Python, C++, or similar). Additionally, the candidate will develop soft skills encompassing report writing, effective literature search, preparation of progress meetings and presentation of research findings. |
| **Job opportunities** | In the current landscape, fostering sustainable practices in space utilization has become a central concern for numerous entities, encompassing several companies, governmental agencies, and educational institutions. Notably, this research endeavors to progress in tandem with the following initiatives: 1. The European Space Surveillance and Tracking Support Framework 2. ESA's Space Safety/Space Traffic Management program 3. Any national initiatives aiming at establishing/improving a national SSA/STM capability. Demonstrating a deep understanding of the theoretical foundations and practical applications explored within this study will greatly enhance the candidate's standing within the space community. |
| **Composition of the research group** | 0 Full Professors<br>2 Associated Professors<br>2 Assistant Professors<br>8 PhD Students |
| **Name of the research directors** | Prof. Pierluigi Di Lizia |

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

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

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