



PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 38th cycle

**PARTENARIATO PNRR Research Field: ENHANCED RADAR SENSOR TECHNOLOGIES
AND DATA PROCESSING PIPELINES FOR SPACE SURVEILLANCE AND TRACKING**

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 space sector is nowadays a symbol of international cooperation and a meeting point of multiple disciplines. Space is an environment shared by all humanity, and it needs, more than anything else, the collaboration of governmental entities and private companies to guarantee its sustainable use. In this context, Space Situational Awareness (SSA) constitutes one of the capacitive areas of strategic interest for the Nations that consider access to space as a main target. Within this program, the European Space Surveillance and Tracking (EU-SST) is the part related to the capability to build a spatial mapping of the objects in orbit, classify them and estimate their orbital motion. SSA is a rapidly growing concern for the global space community today, primarily due to the increase in the space population. Currently, there is no ground sensor with the double characteristic of having a wide Field of View (FoV) to provide the surveillance of a large area of the sky and a high enough accuracy and sensitivity to detect small objects which, according to the North American Aerospace Defence Command (NORAD) catalog and ESA Master model, constitute most objects orbiting Earth. Due to a large number of uncontrolled debris, conjunction events are increasingly likely and less predictable due to insufficient quality of available data and processing algorithms. With the expansion of space activities pushed by the new space economy, these problems are generating increasing commercial and defense interests. The objective of this research is to



	<p>improve SSA services for the near-Earth region through the development of innovative observation strategies and processing algorithms. Such activity shall regard both general applications and procedures tailored for the Bistatic Radar for LEO Survey (BIRALES), an Italian bistatic radar system devoted to space surveillance, which is undergoing an upgrade process. An adaptive beamforming technique is being implemented to electronically track the target even without any orbital prediction, by obtaining a more accurate angular track recorded. From a hardware perspective, the features of the new BIRALES configuration will allow it to adapt to the type of service required by adjusting its FoV and gain depending on the goal (e.g., orbit determination, re-entry monitoring, and more). In addition, BIRALES will be combined with the Noto Radiotelescope (Sicily) to obtain a multistatic radar configuration. CUP C53C22000880006, D.D n. 371 del 11.10.2022</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>This research aims to improve the state of the art on orbit determination processes, for both cataloged and newly detected objects, by exploiting the improved BIRALES sensor, either as a reference baseline or to develop tailored algorithms. In the latter case, the candidate will exploit both the remarkable advantage derived from the adaptive beamforming technique and the multistatic configuration obtained through the Noto Radiotelescope. In addition, the candidate will assess the benefits of the resulting procedures (by possibly developing tailored approaches) for the SST services of conjunctions, re-entry, and fragmentations. In the framework of this research, the candidate will have the opportunity to pursue further activities, which are outlined as follows. First of all, the candidate will acquire a strong knowledge of uncertainty representation and propagation and will develop techniques to characterize the observed target, by estimating its tumbling and attitude from the acquired measurements. Then, the Ph.D. aspirant will investigate proximity operations and, for this aim, will develop a strong understanding of relative orbital dynamics. In particular, advanced techniques for uncertainty quantification will need to be developed to address those</p>



	<p>scenarios where the relative separation between targets is small. The quantified uncertainties may then be used to advise operators about innovative strategies and trajectory plans to conduct or monitor proximity operations. This activity is strictly connected to the target object characterization, as the estimated attitude profiles may represent an added value to the proximity operation monitoring. A third scenario to be explored is the detection and characterization of anomalies in the behaviour of operative satellites. In particular, the candidate shall acquire a strong knowledge of manoeuvres detection techniques and develop innovative approaches based on the orbit determination result and in the measurements space. Throughout all the activities, the candidate will have the chance to take advantage of Artificial Intelligence (AI) techniques by developing AI-based operational procedures to monitor high-interest events. During the research, the candidate will test the developed approaches on data obtained by the BIRALES sensor.</p>
Educational objectives	<p>This research involves the knowledge of the current state of SSA services and their capabilities, thus leading to the training of a professional figure able to effectively interact in such an international context. The practical implementation of the earlier mentioned analysis must pass through a literature review of the current state of the art of these strategies and methods, thus leading to an improvement in the scientific knowledge of the candidate. This will contribute to training a highly qualified researcher that will be able to tackle current space-related issues in order to contribute to the enhancement of the space sector. The candidate will gain profound knowledge about the concepts related to the fields of astrodynamics, estimation techniques, numerical methods, mathematical modelling, and computer programming. Soft skills in writing reports, searching bibliographic resources, preparing progress meetings, and presenting work advancements will also be achieved.</p>
Job opportunities	<p>Activities aiming at guaranteeing a sustainable use of space are nowadays the focus of several companies, national agencies, and universities. Deep theoretical and</p>



	practical knowledge of the topics investigated in this research will ensure a high appeal for the candidate in the space community. The research will develop in parallel to the establishment of 1. The European Space Surveillance and Tracking Support Framework 2. ESA's Space Safety/Space Traffic Management programme 3. Any national initiatives aiming at establishing/improving a national SSA/STM capability All programmes support the development of a network of European and national infrastructures to ensure the long-term availability of space surveillance services, including any existing/future SSA services. To this purpose, both programmes are fostering industrial and academic excellence in the field, which will need the long-term support of experienced professionals.
Composition of the research group	0 Full Professors 2 Associated Professors 0 Assistant Professors 9 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)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	2100.0 €
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 and 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.

