Politecnico di Milano

PhD in
Aerospace Engineering

Research Title: Multibeam radar technology for space-based infrastructures surveillance and satellite reentry monitoring

Scholarships and Financial support	
Monthly net income of PhD scholarship (max 36 months)	€ 1325,00 (In case of a change of the welfare rates during the three-year period, the amount could be slightly modified)
Number of scholarships	1
Beginning of PhD	1 November 2019
Deadline for application	11 September 2019
Context of the research activity	
Motivations and objectives of the research in this field	Satellites travel far above the Earth. Yet they are close enough to threaten our daily lives in case of in-space collisions or reentry into Earth's atmosphere. Satellites provide crucial (but often overlooked) services to people worldwide. Collisions may jeopardize such services and their vital contribution to the economic and social development on Earth. Furthermore, the uncontrolled reentry of large space debris can pose non-negligible property damage and casualty risk. Among the several actions taken worldwide, an international effort is being devoted to improving the performance of optical and radar sensors for space surveillance. Within this framework, the advantage that multibeam radar sensors can offer relies on the fact that, besides providing classical range and range-rate information, the data gathered by the multiple beams can be processed to estimate angular profiles, combining the peculiarities classically assigned to radar and optical

	telescopes into a single sensor. The proposed research aims at developing advanced data-analytic methods to o process the data provided by multibeam radars during the passage of space debris inside the sensor field of view o derive information about the orbit of the observed objects, even using the observational data collected during a single passage of an uncatalogued object o correlate two or more observations of the same object to enhance orbit knowledge and to support space surveillance and satellite reentry campaigns
Methods and techniques that will be developed and used to carry out the research	The research aims at improving the determination of the motion of space debris around the Earth by an innovative combination of orbit determination techniques and multi-receiver data processing methods. The general problem of determining the orbit of an object moving in space can be reduced to comparing the observational data obtained with ground sensors with their mathematical prediction. To this aim, accurate mathematical models are needed to predict the orbital motion and to map the resulting orbital state into the measured quantities. Moreover, the peculiarity of multibeam radar sensors allow us to leverage on the use of data provided my multiple receivers simultaneously. To take full advantage of this potential, the developed techniques must prove to be able to process significant amount of raw data by relying on advanced data-analytic methods, such as dynamic beamforming and machine learning techniques. To this aim, the research will establish an innovative processing chain based on a statistically optimal formulation of the problem of detecting space debris and estimating their dynamics. The key element of novelty over current approaches is that signal analysis will be based on the raw data acquired at the receivers rather than on pre-processed data. This will allow us to make use of all the physical information enabled by microwave physics, by implementing adaptive tracking techniques and super-resolution array processing, as well as by considering residual synchronization between the clocks at the transmitter and at the receivers.
Educational objectives	The main educational objectives are: • the integration of space and radar engineering competences with advanced data-analytics techniques to build a unique interdisciplinary profile • the development of key capabilities in the fervent area of space surveillance and tracking
Job opportunities	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 Both programmes support space monitoring actions to protect Earth and space-based infrastructures from space debris. In so doing, they are fostering development in the field, thereby creating market opportunities.
Composition of the research group	Number of Full Professors: 0 Number of Associate Professors: 1 Number of Assistant Professors: 2
Names of the research directors	Pierluigi Di Lizia
Contacts	pierluigi.dilizia@polimi.it ph.: +39 02 2399 8370

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

Educational activities: financial aid per PhD student per year
1st year: max € 0 per student
2nd year: max € 1534 per student
3rd year: max € 1534 per student
During eventual research periods spent abroad the monthly scholarship will be increased by about 43%. PhD Candidates may spend up to 6 months abroad for their research activity. Additional travel funding are available within the research group.

Teaching assistantship:
availability of funding in recognition of supporting teaching activities by the PhD student
There is the possibility to get financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

Computer availability:
Individual personal computer and access to world-class high-performance computing, if necessary

Desk availability:
1st year: individual use
2nd year: individual use
3rd year: individual use

There is the possibility to get financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations. Individual desk and individual personal computer will be provided. PhD students have access to fixed amount of funding to participate to summer schools and conferences and to buy research/educational materials.