POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 40th cycle

THEMATIC Research Field: OPTIMIZING STRATEGIES FOR ENHANCED LAUNCH MONITORING AND SATELLITE REENTRY PREDICTIONS

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 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	In recent years, in orbit population has become a relevant issue for space agencies and institutions worldwide. Only a small fraction of the orbiting objects are co-operative satellites and the majority is space debris, which includes inactive satellites, rocket bodies, and fragments of all sizes. Space debris poses a threat to space activities, as a collision in orbit could have catastrophic consequences. Therefore, various strategies have been implemented to ensure safe operations, and an international commitment is currently underway in the field of Space Situational Awareness, with focus on the Space Surveillance and Tracking (SST) applications. These currently use measurements from ground-based sensors. Among the SST services, launch monitoring and re-entry analysis are of key importance. Payload launches are monitored to identify possible conjunctions with resident space objects, as well as to establish the related collision risk. Reentry of space objects is directly linked to the risk of casualties on the ground and thus poses a threat to people and infrastructures. The number of payloads launched, and objects reentered is increasing. In the case of the latter, this is also happening for safety reasons, e.g. to comply with the mitigation guidelines of the Inter-Agency Space Debris Coordination Committee (IADC). In addition, the peculiarities of satellite launches and reentries into and from highly elliptical orbits, as well as the growing interest in the cislunar environment, require specific operational monitoring procedures for these orbital regimes to reduce

	prediction errors. The object trajectory must be properly reconstructed and propagated during monitoring. This operation has to be performed taking into account the uncertainties affecting the available ephemeris. To this end, measurements from ground-based sensors are widely used to perform orbit determination. In addition, the acquired observational data can be further processed to gain insight into the target attitude and rotational motion. This knowledge is beneficial to improve orbital propagation, allowing finer predictions. The research aims to improve launch monitoring and re-entry campaign characterization through advanced data processing techniques, uncertainty representation and propagation methods, possibly exploiting ground-based and space-based sensors.
Methods and techniques that will be developed and used to carry out the research	The research aims to improve launch monitoring and re-entry characterisation. Firstly, the candidate will become familiar with the observational data provided by optical, radar and laser sensors. Strong expertise will be acquired in the processing of the signal data required for orbit determination in such scenarios, with particular emphasis on radar range, which is crucial for accurate estimation of the orbital state of the target at low altitudes. For the launch phase, techniques will be developed to automatically identify possible conjunctions in Earth orbits with catalogued objects and to assess the associated risk using deterministic and stochastic approaches. For the re-entry campaigns, advanced target pose estimation methods will be investigated to improve the characterisation of the re-entering target in terms of dimensions, attitude and tumbling motion. The initial information will be integrated with the ballistic coefficient estimated from satellite ephemerides. The knowledge gained and the approaches developed will be used to improve the quality of launch and re-entry monitoring. In particular, it will be essential to develop algorithms to automatically identify which category of sensors can best contribute to the campaign, and at what frequency, depending on the launch and re-entry scenario. This will also be crucial to better assess the re-entry campaign for objects re-entering from highly elliptical orbits and from

	cislunar regions. Overall, the candidate will also acquire a strong knowledge of uncertainty representation and propagation in order to integrate the developed methods with a stochastic approach. This is essential in the highly perturbed environment that the satellite traverses during the re-entry phases.
Educational objectives	The research concerns the SSA/SST field, which involves both governmental institutions and private companies at a national and international level. The candidate will have the possibility to interact in this context, developing both technical and soft skills. From a technical point of view, the candidate will gain a deep knowledge of signal data processing, astrodynamics, numerical methods, uncertainty representation and propagation, and computer programming. In addition, joining the research team will require to take part in progress meetings, where the candidate will be asked to present work progress and make shared decisions with the group. All these aspects will contribute to training a highly qualified researcher who will be able to tackle current space-related projects and contribute to the enhancement of the space sector.
Job opportunities	Space Traffic Management (STM) is nowadays the focus of several companies, national agencies and universities. The skills acquired on the research topics will ensure the attractiveness of 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 program. 3. Any national initiative aiming at establishing/improving a national SSA/STM capability. All programs 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 service. To this purpose, all programs 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 2 Assistant Professors

	15 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	750.0 €
By number of months	6

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