POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

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

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	In recent years, in orbit population has become a remarkable problem for space agencies and institutions all around the world. Among orbiting objects, just a small fraction is represented by co-operative satellites and the main part is composed of space debris, which includes inactive satellites, rocket bodies, and fragments of all sizes. Space debris represents a threat to space activities, as an in-orbit collision could imply catastrophic consequences. Therefore, different strategies have been implemented to guarantee safe operations, and an international commitment is currently taking place in the Space Situational Awareness field, with a focus on the Space Surveillance and Tracking (SST) applications. These currently exploit measurements obtained through ground-based sensors. Among SST services, the satellite re-entry analysis has become of key importance, as it implies an on-ground casualty risk, thus constituting a threat to people and infrastructures. The number of objects re-entering for safety reasons is increasing, e.g. to comply with the mitigation guidelines of the Inter-Agency Space Debris Coordination Committee (IADC). In addition, the peculiarities of satellite re-entry from highly-elliptical orbits, as well as the growing interest in the cislunar environment, calls for dedicated operational procedures to monitor satellites re-entering from these orbital regimes. To monitor satellite re-entries, the object trajectory shall be properly reconstructed and propagated. This operation shall be accomplished considering the

	uncertainty affecting the available ephemeris. To this end, measurements acquired through on-ground sensors are widely used to conduct orbit determination in the first epochs of the de-orbiting phase, when the predicted target state can be considered reliable, as well as when the target is transiting through the low layers of the atmosphere. Moreover, the acquired observational data can be further processed to have an insight into the target pose and rotational motion, and so, whether the re-entry is being conducted in a controlled or an uncontrolled manner. This knowledge is also beneficial to improve orbital propagation, allowing a finer re-entry prediction. The research aims to improve the re-entry campaign characterization through advanced data processing techniques, uncertainty representation and propagation methods, and by exploiting both on-ground and space-based sensors.
Methods and techniques that will be developed and used to carry out the research	The research aims at improving the re-entry campaign characterization. First, the candidate will become familiar with the observational data provided by optical, radar and laser sensors. In particular, a strong expertise will be acquired in processing the signal data needed to run an orbit determination, with particular emphasis on radar range, which is crucial to accurately estimate the target orbital state in the last epochs before the re-entry. In addition, advanced methods for the target pose estimation will be investigated, such as those based on radar imaging and laser ranging. This will allow the development of approaches to improve the re-entering target characterization in terms of dimensions, attitude and tumbling. The first information will be integrated with the ballistic coefficient estimated using additional satellite ephemerides (those available on public catalogues for instance) to provide a physical parameter to be exploited in the forward orbital propagation. The acquired knowledge and developed approaches will be exploited to improve the quality of the re-entry monitoring and prediction, by taking profit of available orbital ephemerides, as well as data from on-ground and space-based sensors. In particular, it will be fundamental to develop algorithms to automatically identify which

	category of space-based sensors can contribute most to the campaign, both in terms of the orbital regime and sensor characteristics and with which frequency measurements shall be acquired, depending on the re-entry scenario. This will be crucial also to better assess the re-entry campaign for objects coming from cislunar regions, as well as from highly elliptical orbits. Overall, the candidate will also acquire a strong knowledge of uncertainty representation and propagation, to integrate the developed methods with a stochastic approach. This action is fundamental considering the highly perturbed environment the satellite crosses during the re-entry phases. Throughout all the activities, the candidate will have the chance to interact with the research group, which has gained strong expertise in the SSA and SST fields. In addition, it will be possible for the candidate to take advantage of Artificial Intelligence (AI) techniques and additional computational tools developed in Politecnico di Milano, and of real data acquired by national and European sensors.
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. Furthermore, the literature review will provide the candidate with the tools to search bibliographic resources. In addition, joining the research team will require the candidate to take part in progress meetings, present the work progress and write reports. 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 programme. 3. Any national initiative 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 service. 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 2 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Pierluigi Di Lizia

Contacts
Dipartimento di Scienze e Tecnologie Aerospaziali - Politecnico di Milano - via La Masa 34, 20156 Milano - Italy - tel. +390223998323 - fax +390223998334 - email: pierluigi.dilizia@polimi.it - web site: www.aero.polimi.it

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

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.