



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

**THEMATIC Research Field: ORBITAL CARRYING CAPACITY ASSESSMENT WITH LONG-TERM DEBRIS SIMULATIONS AND SPACE DEBRIS INDICATORS**

**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 population of space debris has increased over the past decades including inactive satellites, rocket bodies and fragments generated from breakups in space due to collision events and explosions. Collisions with debris fragments objects can lead to the failure of operational missions and increase the operational cost for more often collision avoidance manoeuvres. Breaks up can occur also due to the failure of subsystems of inactive spacecraft such as batteries and propulsion systems and more and more such events are identified. When a break-up event takes place and is communicated on-ground telescopes of the Space Surveillance Tracking networks are tasked to identify new fragments so that unrelated fragments appear in the available debris catalogues. Long-term integration of the space debris environment allows having estimation of the evolution of the space debris population under different hypotheses for space activities. Moreover, several space debris indexes have been proposed to assess the impact of a single mission on this very delicate environment. The aim of this PhD is to develop and use long-term debris simulators for assessing the evolution of space debris over the next 200 years and define space debris indicators to assess the impact that each mission has on the space debris ecosystem. The developed tools and techniques will be applied within the Inter-Agency Space Debris Coordination Committee.



**Methods and techniques that will be developed and used to carry out the research**

This PhD research will apply tools and techniques based on semi-analytical propagation, density-based fragment cloud propagation, and uncertainty propagation techniques developed within the COMPASS group to different applications in the field of space debris mitigation.

Based on the work done on the development of the THEMIS tool for the evaluation of the environmental effect of a mission onto the environment, we will develop a simplified surrogate model for the fast evaluation of such an effect by the spacecraft operator. Such a model will be also applied, together with other indicators to evaluate the evolution in time of the overall space capacity. The tool Starling 2.0 and the long-term debris model will be used to perform long-term simulations for the evolution of space debris and identify proxies to assess the orbital carrying capacity from a long-term simulation point of view. The Starling 2. tool and the long-term debris simulator COMETA will be extended to use the launch traffic used within the IADC and the solar activity model. Moreover, a validation campaign will be performed.

Concepts like the collision risk in different orbital regions or the estimated amount of collision avoidance manoeuvres will be evaluated and compared with the aggregated space debris index. Long-term simulations will be also used to characterise the impact of past and future space activities on the orbital environment and the impact of shorter deorbit recommendations.

**Selected references**

- Muciaccia A., Giudici L., Trisolini M., Colombo C., del Campo B., Letizia F. Lemmens S., "Space environment investigation using a space debris index", 9th Annual Space Traffic Management Conference, Austin, Texas, 01-02 Mar. 2023.
- Colombo C., Muciaccia M., Giudici L., Gonzalo J. L., Masat A., Trisolini M., del Campo B., Letizia F., Lemmens F. "Tracking the health of the space debris environment with THEMIS", EUCASS-CEAS Conference 2023, 9-13 Jul. 2023, Lausanne.
- Giudici L., Colombo C., Horstmann A., Lemmens S., Letizia F., "Continuity equation-based model for the assessment of the long-term effect of mitigation and remediation measures on the space debris environment",



	Second International Orbital Debris Conference (IOC II), Dec. 4–7, 2023, Sugar Land, Texas.
<b>Educational objectives</b>	The objective of this PhD is to develop skills in the dynamical system theory and long-term orbit evolution, modelling of space debris and definition of space debris indicators. Through this PhD project, the candidate will develop skills in mathematical development, simulations, programming (Matlab, Phyton), and high-performance computing through CPU and GPUs. Being this PhD funded through a research contract, soft skills in presenting the research, writing reports, developing operational code, outreach, dissemination, and preparing industrial progress meetings will be also achieved through the PhD work. The PhD candidate will be also involved in the research, industrial projects, and organisational and outreach activities of the group. For further information on the project visit: <a href="http://www.compass.polimi.it">www.compass.polimi.it</a>
<b>Job opportunities</b>	Job opportunities after a PhD on this topic can be in any of the space agencies, in particular the European Space Agency, the Italian Space Agency and the several European companies and research institutions involved in space debris mitigation, space traffic management, space situational awareness, space policies and mission design.
<b>Composition of the research group</b>	0 Full Professors 1 Associated Professors 2 Assistant Professors 12 PhD Students
<b>Name of the research directors</b>	Prof. Camilla Colombo

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



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.