



PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 40th cycle

**THEMATIC Research Field: NEW APPROACHES AND SOFTWARE DEVELOPMENT FOR
TRACKING THE HEALTH OF THE ENVIRONMENT AND MISSIONS IN SPACE**

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**

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. The THEMIS software was conceived to assess the impact of a space mission on the space debris environment, and to determine the share of the capacity of Space used by the mission under analysis. The THEMIS approach also allows the computation of the overall share of the Space capacity used by orbiting spacecraft and to analyse possible definitions of the capacity of orbital space and what its threshold should be. On the other side, long-term simulations of the space debris environment allows having estimation of the evolution of the space debris population under different hypotheses for space activities. Together with space debris indexes they can be used to assess the impact of a single mission on this very delicate environment [1,2]. The aim of this PhD is (1) to develop novel techniques approaches for extending the capabilities of the THEMIS software to the geostationary region and (2) to extend its use to assess the overall space orbital carrying capacity. Moreover, (3) a large task in the software implementation using python is foreseen following an Agile approach.

Selected references

[1] THEMIS software

<https://indico.esa.int/event/511/page/823-themis-final->



	<p>presentation-and-demonstration</p> <p>[2] 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</p> <p>[3] 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.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>This PhD research is twofold, on the modelling point of view the computation of the THEMIS index need to be extended to GEO region [4] and the THEMIS approach for the evaluation of the space capacity is to be further developed based on the current work performed at Politecnico di Milano [3] The capacity concept defined in THEMIS combines the space debris index and the long-term projection of the space environment obtained with DELTA. The risk metric derived in THEMIS is used to compute the aggregated index, i.e., the sum of the indexes of all in-orbit missions at a given epoch. The DELTA software estimates the future trend of the in-orbit population under the different scenarios in terms of launch traffic, explosion rate, disposal strategies and reliability. Long term simulations with DELTA will be run to compute the total index on all the objects generated in simulation with yearly snapshots. The second goal is to perform the software development for the improvement of the THEMIS software funded by a European Space Agency project. User stories will be defined by the technical team to fill the gap in the current software. Based on them, following an Agile approach, the successful candidate will be involved in the software development part of the backend API of THEMIS and the inner algorithm in Python.</p> <p>[4] Lorenzo Giudici, Juan Luis Gonzalo, Andrea Muciaccia, Camilla Colombo, Mirko Trisolini, Francesca Letizia, "Environmental impact of object breakup in medium-Earth orbit", Advances in Space Research, Vol. 74, Issue 4, 2024, pp. 1900-1915,</p>



	https://doi.org/10.1016/j.asr.2024.06.012 .
Educational objectives	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 and software development. Through this PhD project the candidate will develop skills in mathematical development, simulations, programming (Python and API development), high performance computing through CPU. 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, organisational and outreach activities of the group. For further information on the project visit: www.compass.polimi.it
Job opportunities	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.
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 13 PhD Students
Name of the research directors	Camilla Colombo

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.