

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 41st cycle

THEMATIC Research Field: ADVANCED MODELLING OF THE IMPACT OF SPACE MISSION AND SPACE CONSTELLATIONS TO SPACE SUSTAINABILITY

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.

Con	text of the research activity
Motivation and objectives of the research in this field	Space assets in orbit around the Earth and beyond offer services of social and economic benefit to humankind and allow monitoring the conditions on our delicate planet. The 2030 Agenda for Sustainable Development, subscribed by all the United Nations (UN) member states in 2015, set 17 Sustainable Development Goals (SDGs) towards a sustainable thriving of humankind and the planet. As recognised by the UN and space agencies, space missions contribute to the achievement of the SDGs and support through remote sensing mission and telecommunication mission sustainability on Earth. On the other side, as our life is becoming more and more interconnected thanks to satellites, and space is more easily accessible, the impact of space missions and generated space debris on the Space environment is very large, not only for the number of space debris but also as a disturbance of astronomical observations from ground. To ensure the long-term sustainability of space activities it is important to assess the impact of space debris and space missions on the long term sustainability of the space environment, both in terms of space debris impact and in term of light pollution and atmosphere pollution.
Methods and techniques that will be developed and used to carry out the research	This PhD research is part of the GREEN SPECIES project funded by the European Research Council. The goal of this research is to develop an advanced models for aspect of mission sustainability to be then assessed in a multi- objective optimisation framework to define the optimal



objective optimisation framework to define the optimal mission design that respond to these indicators. First to allow the evaluation of the impact of space mission on space sustainability different models will be developed. A model for assessing the impact of a space constellation to light pollution will be developed [1]. Such approach measures the brightness of a spacecraft belonging to a constellation as function of spacecraft design, constellation architecture and orbit design. The model will be validated thanks to a framework of collaboration with space constellation operators within the Global Space Operators Association (GSOA) to enhance the adherence of large constellations to the GSOA Code of Conduct. Then, extending previous work at Politecnico di Milano on a space debris indicator that measures the risk generated by space missions in space [2], a criterion to select active debris removal target for active debris removal missions will be also defined [3]. Finally, also the social benefit contribution of a mission to the achievement of the Sustainable Development Goals will be modelled in terms of orbit design, payload characteristics and mission architecture [4]. The developed models will be used in a multi objective optimisation framework to select Pareto optimal solutions for space mission design and to be used for controlling the overall increase of the space debris population. The results will contribute to define an engineering-based quantitative space sustainability assessment [5]. [1] Littoriano G., Colombo C., Nastasi A., Falco C., "Modelling of spacecraft apparent brightness A study on OneWeb constellation satellites", Advances in Space Research, Vol. 74, Issue 3, 2024, pp. 1392-1409. [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. [3] G. Borelli, M. Trisolini, M. Massari, and C. Colombo. "A comprehensive ranking framework for active debris removal missions' candidates". 4 2021. [4] Santoro V. and Zuliani C., "Social benefits assessment of Earth observation missions through the Sustainable Development Goals 2030". MSc. Thesis in Aerospace



	Engineering, Politecnico di Milano, Italy, 2021. Supervisors: Colombo C., Nugnes M. [5] Lanfredi Alberti C., "Advancing the General Space Sustainability - OneWeb Commitment and Light Pollution and Active Debris Removal Indices Integration in SSR". 2023, Politecnico di Milano, MEng in Space Engineering, Supervisors: C. Colombo, P. Minguijon-Pallas, A. Muciaccia
Educational objectives	The objective of this PhD is to develop skills in the modelling of the impact of a space mission to space sustainability. Through this PhD project the candidate will develop skills in mathematical development, numerical simulations and analysis, multi-objective optimisation, programming (Matlab, Python, C++ or similar), parallel computing and Agile approach. Soft skills in presenting the research, writing reports, outreach, dissemination, will be also achieved through the PhD project. As this PhD is funded by projects, the PhD will also achieve skills in project management and preparing industrial progress milestone meetings. For further information on the project visit: www.compass.polimi.it and contact Camilla Colombo. References: [1] Littoriano G., Colombo C., Nastasi A., Falco C., "Modelling of spacecraft apparent brightness A study on OneWeb constellation satellites", Advances in Space Research, Vol. 74, Issue 3, 2024, pp. 1392-1409. [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. [3] G. Borelli, M. Trisolini, M. Massari, and C. Colombo. "A comprehensive ranking framework for active debris removal missions' candidates". 4 2021. [4] Santoro V. and Zuliani C., "Social benefits assessment of Earth observation missions through the Sustainable Development Goals 2030". MSc. Thesis in Aerospace Engineering, Politecnico di Milano, Italy, 2021. Supervisors: Colombo C., Nugnes M. [5] Lanfredi Alberti C., "Advancing the General Space



	Sustainability - OneWeb Commitment and Light Pollution and Active Debris Removal Indices Integration in SSR". 2023, Politecnico di Milano, MEng in Space Engineering, Supervisors: C. Colombo, P. Minguijon-Pallas, A. Muciaccia
Job opportunities	This position prepares to the role of Space Sustainability engineer that is an emerging career path at large constellation and space operators companies. Job opportunities after a PhD on this topic can be in any of the space agencies, in particular the European Space Agency and the several European companies involved in space traffic management, space situational awareness, space policies and mission design. The current research prepares the PhD candidate to both academic and industrial careers. Knowledge of modelling and simulation of space assets and operations are fundamental skills for careers in space-related companies and universities.
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 15 PhD Students
Name of the research directors	Camilla Colombo

Contacts

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

Additional support - Financial aid per PhD student per year (gross amount)		
Housing - Foreign Students		
Housing - Out-of-town residents		

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

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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.