Curriculum vitae – Paolo Lunghi

1 Personal details

Dr. Paolo Lunghi

Building B12
Department of Aerospace Science and Technology
Politecnico di Milano

via La Masa, 34
20156 Milano, Italy

Phone: +39 02 2399 8041

Email: paolo.lunghi@polimi.it

Website: www.paololunghi.com

Researcher identifiers: AAG-7981-2019;

SC 56288757500;

0000-0002-9501-1049.

Contents

2   Current and previous positions

01/07/24 – onward   **Tenured Assistant Professor** (*Ricercatore a tempo determinato L.240/10 RTT*).
                    Politecnico di Milano, Italy, Department of Aerospace Science and Technology.
Area: 09/IIND-01 – Aeronautical and aerospace engineering and naval architecture.
Discipline: IIND-01/E – Aerospace equipment and systems.
Research topics: Spacecraft Dynamics; Autonomous Guidance, Navigation, and Control systems; Vision-based Navigation; Spacecraft Autonomy; Trajectory Optimization; Entry, Descent and Landing Optimization; Microgravity Research.

01/10/18 – 30/09/23 **Untenured Assistant Professor** (*Ricercatore a tempo determinato L.240/10 tipo A*).
                    Politecnico di Milano, Italy, Department of Aerospace Science and Technology.
Area: 09/IIND-01 – Aeronautical and aerospace engineering and naval architecture.
Discipline: IIND-01/E – Aerospace equipment and systems.
Research topics: Spacecraft Dynamics; Autonomous Guidance, Navigation, and Control systems; Vision-based Navigation; Spacecraft Autonomy; Trajectory Optimization; Entry, Descent and Landing Optimization; Microgravity Research.

01/02/17 – 30/09/18 **Postdoctoral Fellow**.
                    Politecnico di Milano, Italy, Department of Aerospace Science and Technology.
Research topics: Spacecraft Dynamics; Autonomous Guidance, Navigation, and Control systems; Spacecraft Autonomy; Trajectory Optimization; Entry, Descent and Landing Optimization; Microgravity Research.

08/01/16 – 15/07/16 **Visiting researcher**.
                    University of California, Irvine (CA, USA) Department of Mechanical and Aerospace Engineering.
Supervisor: Prof. Kenneth D. Mease.
Research topics: Atmospheric entry trajectory optimization for autonomous pinpoint landing on Mars, as member of the *Flight Dynamics and Control Lab*.

01/05/13 – 31/10/14 **Research Assistant**.
                    Politecnico di Milano, Italy, Department of Aerospace Science and Technology.

3   Education

23/01/2017   **PhD in Aerospace Engineering**.
             Politecnico di Milano, Italy, Department of Aerospace Science and Technology.
Thesis title: Hazard detection and avoidance systems for autonomous planetary landing.
Supervisor: Prof. Michèle Lavagna.

23/04/2013   **MSc in Space Engineering, 110/110**.
             Politecnico di Milano, Italy, Department of Aerospace Science and Technology.
Thesis title: Robust control for planetary landing maneuvers.

23/10/2008   **BSc in Aerospace Engineering, 108/110**.
             Politecnico di Milano, Italy, Department of Aerospace Science and Technology.
Thesis title: Produzione di trasparenti aeronautici: controlli in ingresso delle materie prime.
                 Aeronautical windows manufacturing: incoming inspection of raw materials.

4 Participation in research groups activities

01/11/13 – onward **Space Mission Engineering (SME) Laboratory**.

Politecnico di Milano, Italy, Department of Aerospace Science and Technology.

Coordinator: Prof. Franco Bernelli Zazzera.

Web: https://www.aero.polimi.it/en/research-labs/sme--14

The laboratory entails all the personnel involved in space related research activities at the Department of Aerospace Science and Technology. It counts 14 faculty members, with the related graduate and undergraduate students. The group established many collaborations with Italian and international universities, research centers, and space agencies.

01/11/13 – 30/01/23 **Advanced Space Technologies for Robotics and Astrodynamics (ASTRA)**.

Politecnico di Milano, Italy, Department of Aerospace Science and Technology.

Coordinator: Prof. Michèle Lavagna.

The group carries out research on astrodynamics, Guidance Navigation and Control, autonomous space systems, In Situ Resource Utilization, design and implementation of CubeSat missions. Collaborations are in place with the main universities, agencies, companies, and research centers, in Italy and international, in the space research field. The group manages some experimental facilities: a clean-room for CubeSat integration, an experimental plant to test oxygen extraction from lunar regolith by high temperature oxidation-reduction, a test bench for vision-based navigation systems in planetary landing, and close proximity maneuvers.

08/01/16 – 30/06/16 **Flight Dynamics and Control Laboratory**.

University of California, Irvine, UCI Samueli School of Engineering – Department of Mechanical and Aerospace Engineering.

Coordinator: Prof. Kenneth D. Mease (now Prof. Emeritus).

I was involved as visiting PhD student, conducting research on autonomous planetary entry guidance. The group established many international collaborations, the most notably ones with Jet Propulsion Laboratory, NASA Marshall Space Flight Center, NASA Ames Research Center, National Science Foundation, Boeing, Princeton University, Politecnico di Milano, Universitat Autonoma de Barcelona.

5 Involvement in research and industrial projects

2021 – 2023 **Ariadna – Investigation of low energy Spiking Neural Networks based on temporal coding for scene classification**. Investigation on the potential benefits of ultra-low energy Spiking Neural Networks based on temporal coding for embedded AI applications in space, applied on the case study of land use classification based on the EuroSAT dataset.

Role: Principal Investigator.

Funding source: European Space Agency (ESA).

Amount (EUR): 29 500

Collaboration: Politecnico di Milano, ESA Advanced Concepts Team.

2018 – 2023 **High Energy Rapid Modular Ensemble of Satellites – HERMES**. Design, development, and integration of a constellation of 3U CubeSats aimed to an IOD to verify the feasibility to rapidly detect, identify, and triangulate Gamma Ray Bursts in the sky.

Role: Head of System Engineering (SE), contributor to proposal preparation (H2020).

(Continued)

As SE head for the development of the spacecraft bus, I coordinated a team of 16 people through the 0/A, B, and C mission phases. The program, in which I'm no longer involved, is still running and it's currently in phase D, aiming for a launch in late 2024 or early 2025.

Funding source: Italian Ministry of University and Research (MUR), European Commission.

HERMES is a large program, consisting in two complementary contracts: an Italian grant issued by the MUR (HERMES-TP), and a EC H2020 grant (HERMES-SP: SPACE-20-SCI-2018, grant no. 821896).

Collaboration: Italian Space Agency (ASI), Italian National Institute of Astrophysics (INAF), Politecnico di Milano, University of Cagliari, Bruno Kessler Foundation, Italian National Institute of Nuclear Physics (INFN), University of Udine, University of Nova Gorica, Skylabs d.o.o., Elecnor Deimos, Aalta Lab, Politecnico di Milano Foundation, Italian Institute of High Mathematics "Francesco Severi" (INdAM), University of Tübingen, C3S, Institute of High energy Physics - Chinese Academy of Sciences, Semmelweis University at Budapest, Konkoly Observatory, Masaryk University at Brno.

2021 – 2022 **AIvionic**. Study on spacecraft vision-based navigation techniques assisted by AI systems, in two mission scenarios: planetary landing and proximity maneuvering around uncooperative target.

Role: Work Package manager (experimental tests).

Founding source: European Space Agency (ESA).

Collaboration: Elecnor Deimos, Politecnico di Milano, Aiko srl., Ubotica Technologies, Fortiss GmbH.

2020 – 2022 **Guide di Luce per Applicazioni multifunzionali per Sistemi Spaziali – GLASS**. Technological study to enhance the TRL of fiber optic sensing systems applied to ultra-flexible structures in space. Involved as designer of microgravity experiments and control systems.

Role: Co-investigator.

Founding source: Italian Space Agency (ASI).

Collaboration: Politecnico di Milano, OST srl.

2020 – 2021 **e.INSPECTOR**. Phase 0/A design for a Cubesat mission to image an EU orbital debris to exploit the obtained images for the verification and validation of the Clear Space One.

Role: Work Package manager.

Founding source: European Space Agency (ESA).

Collaboration: Politecnico di Milano, Leonardo SpA, Leaf Space.

2018 – 2020 **Commercial ISRU Demonstration Mission Preparation Phase**. Phase A design of an ISRU demonstration payload for the extraction of O_2 from lunar regolith.

Role: Co-investigator.

Founding source: European space Agency (ESA).

Collaboration: OHB-IT SpA, Politecnico di Milano, OHB-System.

2017 – 2018 **ISRU System Demonstrator – O_2 Extraction From Lunar Regolith**. Development and testing of a laboratory system demonstrator for the carbothermal reduction of lunar regolith simulant.

Role: Work Package manager.

Founding source: European Space Agency (ESA).

<div align="center">(Continued)</div>

Collaboration: OHB-IT SpA, Politecnico di Milano, OHB-System.

2017   **Lunar ISRU Demonstration Mission Definition Study**. Feasibility study of a lunar plant to extract O_2 from metallic oxides in the lunar regolith. Preparatory for an ISRU demonstration mission in 2025.

Role: Co-investigator.

Founding source: European Space Agency (ESA).

Collaboration: OHB-IT SpA, Politecnico di Milano.

2016   **SatLeash**. Microgravity experiment aimed to investigate the dynamics of space tethers, and possible control laws to handle them. Flown in the 65th ESA Parabolic Flight Campaign, Nov 2016. Responsible of the system OBDH.

Role: Co-team leader.

Founding source: European Space Agency (ESA).

Collaboration: Politecnico di Milano.

2014 – 2015   **GLXP Lander Technology**. Experimental facility development and setting to test optical GNC algorithms for spacecraft planetary landing.

Role: Co-investigator.

Founding source: European Space Agency (ESA).

Collaboration: Politecnico di Milano, TSD srl.

2013   **Study on Flight Control Team Multi-Agent System (FCTMAS)**. Development of a multiagent system for the early detection of spacecraft anomalies based on analysis of operational logs and telemetry data.

Role: Co-investigator.

Founding source: European Space Agency (ESA).

Collaboration: Telespazio VEGA-D GmbH, Politecnico di Milano.

2013   **ESA ITI - Wireless Passive Sensors for Temperature Monitoring Systems**. Development of a demonstrator for thermal wireless passive sensors for space systems AIT/AIV in thermal vacuum chambers.

Role: Co-investigator.

Founding source: European Space Agency (ESA).

Collaboration: Thales Alenia Space Italy, Politecnico di Milano, Leonardo SpA.

6   Teaching activities

2014 – 2023   **Teaching Assistant**.

Politecnico di Milano, Italy, Department of Aerospace Science and Technology.

Courses:

2020 – 2023   *Space Systems Engineering & Operations* (EN), M.Sc. in Space Engineering.

2020 – 2021   *Space Mission Analysis & Design* (EN), M.Sc. in Space Engineering.

2020 – 2021   *Space Structures – Dynamics of Space Structures* (EN), M.Sc. in Space Engineering.

2018 – 2020   *Dynamics and Control of Space Structures* (EN), M.Sc. in Space Engineering.

<div align="right">Continued on next page</div>

(Continued)

2016 – 2019   *Istituzioni di Ingegneria Aerospaziale – Fundamentals of Aerospace Engineering* (IT), B.Sc. in Aerospace Engineering.

2014 – 2017   *Space Mission Analysis & Design* (EN), M.Sc. in Space Engineering.

2014 – 2016   *Orbital Mechanics* (EN), M.Sc. in Space Engineering.

6.1   Teaching qualifications

15/06/2023   **Italian national scientific qualification for Associate Professor**.
                Abilitazione Scientifica Nazionale (ASN) per Professore di II fascia.

Academic field   09/IIND-01 – Aeronautical and aerospace engineering and naval architecture.
(Settore concorsuale)   *Ingegneria aeronautica, aerospaziale e navale.*

7   Supervision experience

As Assistant Professor in Italy, I was able to be a formal supervisor of both PhD and MSc students. Before of that, only informal supervision was allowed. Since 2020 at Politecnico di Milano – Department of Aerospace Science and Technology, (Italy) I co-supervised 3 PhD students, 2 of them foreign ESRs in the *ASCenSIon* MSCA Innovative Training Network (H2020-MSCA-ITN-2019), and 1 of them informally, all of them graduating in Q1 2024. Since 2015 I also supervised 9 MSc theses, 2 of them formally, on the topics of Guidance Navigation and Control, Vision-Based Navigation, Hazard Detection and Avoidance, Space Robotics Systems. I'm currently supervising a MSc thesis (graduation scheduled in 2024) in collaboration with the Space Robotics Laboratory of the Tohoku University (Sendai, Japan), guided by Prof. Kazuya Yoshida and Prof. Toshinori Kuwahara, on the topic of AI-assisted vision-based navigation for autonomous end-to-end lunar missions, from cislunar space to landing. The student, enrolled at Politecnico di Milano, is working partly abroad supported by a MEXT scholarship (issued by the Japanese government).

8   Institutional responsibilities

10/01/2023 – onward   **Member of permanent PhD Committee** (*Collegio dei Docenti*).
                      PhD in Aerospace Engineering.
                      Aerospace Science and Technology Department, Politecnico di Milano, Italy.

9   Fellowship, awards, and commission of trust

9.1   Scientific awards

01/07/2022   Best student paper award, category "Dimensioning" at *9th European Conference for Aeronautics and Aerospace Sciences (EUCASS)*, paper: M. Bechini, P. Lunghi, and M. Lavagna, "Spacecraft Pose Estimation via Monocular Image Processing: Dataset Generation and Validation."

2016   Group award: selected for fly in the 65th ESA Parabolic Flight Campaign with the *SatLeash* experiment. Awarded by the ESA Education Office in the *Fly Your Thesis!* program.

9.2   Scientific societies

2018 – onward   Member of the American Institute of Aeronautics and Astronautics (AIAA).

9.3 Reviewing activities

Since 2015, I've been a reviewer for several journals recognized as high impact in my research field, including: *Acta Astronautica* (Elsevier, ISSN: 0094-5765), *Journal of Guidance, Control, and Dynamics* (AIAA, 1533-3884), *IEEE Transactions on Aerospace and Electronic Systems* (IEEE, 0018-9251), *Advances in Space Research* (Elsevier, 0273-1177), *Journal of Spacecraft and Rockets* (AIAA, 1533-6794), *PLoS ONE* (Public Library of Science, 1932-6203), *Journal of Computational and Nonlinear Dynamics* (ASME, 1555-1423), *Aerospace* (MDPI, 2226-4310), *International Journal of Aerospace Engineering* (Hindawi, 1687-5974), *Space: Science & Technology* (AAAS, 2692-7659).

10 Talks and seminars

10.1 Presentations at international conferences

10/01/2018   **28th Space Flight Mechanics Meeting - AIAA SciTech 2018**.
    Venue: Kissimmee, FL, USA.
    Title: Atmospheric Entry Guidance Based on Differential Algebra for High Elevation Mars Landing.

16/02/2016   **26th AAS/AIAA Space Flight Mechanics Meeting**.
    Venue: Napa, CA, USA.
    Title: Semi-Analytical Adaptive Guidance Computation Based on Differential Algebra for Autonomous Planetary Landing.

11/08/2015   **2015 AAS/AIAA Astrodynamics Specialist Conference**.
    Venue: Vail, CO, USA.
    Title: A Multilayer Perceptron Hazard Detector for Vision-Based Autonomous Planetary Landing.

12/05/2015   **13th Symposium on Advanced Space Technologies in Robotics and Automation, ASTRA 2015**.
    Venue: Noordwijk, The Netherlands.
    Title: Vision-Based Hazard Detection with Artificial Neural Networks for Autonomous Planetary Landing.

01/10/2014   **65th International Astronautical Congress 2014, IAC 2014**.
    Venue: Toronto, Canada.
    Title: Autonomous Vision-Based Hazard Map Generator for Planetary Landing Phases.

04/06/2014   **9th International ESA Conference on Guidance, Navigation & Control Systems, GNC 2014**.
    Venue: Porto, Portugal.
    Title: A Neural Network Based Hazard Detection Algorithm for Planetary Landing.

28/01/2014   **24th AAS/AIAA Space Flight Mechanics Meeting**.
    Venue: Santa Fe, NM, USA.
    Title: Semi-Analytical Guidance Algorithm for Autonomous Close Approach to Non-Cooperative Low-Gravity Targets.

16/05/2013   **12th Symposium on Advanced Space Technologies in Robotics and Automation, ASTRA 2013**.
    Venue: Noordwijk, The Netherlands.

(Continued)

Title: Semi-Analytical Adaptive Guidance Algorithm for Fast Retargeting Maneuvers Computation During Planetary Descent and Landing.

10.2   Invited talks

27/06/2017   **ESA/ELGRA Gravity–Related Research Summer School 2017**, invited speaker.
ESA Academy's Training and Learning Centre, ESA-ESEC, Redu, (Belgium).

Lecture, titled *Fly Your Thesis! 2016 – the SatLeash Experiment*, aimed at graduate students interested in gravity-related research. I reported my experience as participant of the *65th ESA Parabolic Flight Campaign* (Nov 2016) with the *SatLeash* project.

11   Publications

Since 2013 I have published, as main or co-author, 14 peer reviewed articles, 3 datasets, and 43 conference papers (26 of them indexed in Scopus) on Guidance Navigation and Control, Spacecraft Autonomy, Vision-based Navigation, Hazard Detection and Avoidance, In-Situ Resource Utilization, microgravity research. My research is published in international, peer reviewed journals of primary importance in the aerospace engineering field, such as *Aerospace Science and Technology*, *Acta Astronautica*, the *International Journal of Robust and Nonlinear Control*, *Advances in Space Research*.

The complete list of publications can be found at https://paololunghi.com/publication/. Citations and other metrics in the plots below are taken from Scopus on 04/07/2024, excluding self-citations.

Citation metrics

Publications:	**40**
Citations:	**276**
H-index:	**9**
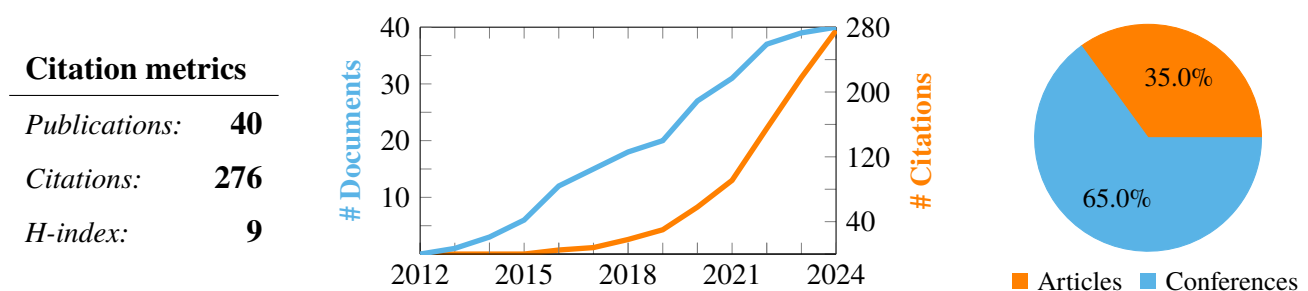
12   Outreach activities

I took part to several outreach activities at schools, events organized by university, and through engagement with cultural centers and the media such as journalists and magazines. In the following, a brief selection is presented.

21/11/2019   Speaker at *Focus Live 2019*, a science popularization event held at the *Museo nazionale della scienza e della tecnologia "Leonardo da Vinci"*, with a seminar titled "Viaggi spaziali: a che punto siamo e dove possiamo arrivare (Space travel: where we are, where we can go)". https://live.focus.it/edizione2019/programma/il-futuro-dei-viaggi-spaziali/

29/10/2019   Speaker at *POLImoon – La Luna in pillole*, A public outreach event organized by Politecnico di Milano held at the Civic Planetarium of Milan to celebrate the 50th anniversary of the first human landing on the Moon, with the talk "Allunaggio e imaging lunare: missione Apollo e nuove sfide (Moon landing and lunar imaging: Apollo mission and new challenges)". https://lofficina.eu/?event=la-luna-in-pillole&event_date=2019-10-29

12/05/2019   Participation in the role of "mentor" at the *1st Italian Space Startup Competition* organized by the Space Generation Advisory Council and held in Milano.

13   Experience

13.1   Research

Autonomous vision-based navigation: design, implementation, and validation of autonomous vision-based navigation systems based on both traditional image processing and Artificial Intelligence techniques, design to assist autonomous operation during mission-critical phases like planetary landing, in-orbit servicing, and close proximity maneuvers around small celestial bodies and other non-cooperative targets. Simulation of vision-based navigation systems with both artificial and analog image generation.

- Multilabelled sImplified taNgo IMage dAtaset (MINIMA): validated, artificial image dataset for development, training, and testing of navigation systems for in orbit close proximity operation, using the Tango spacecraft as case study. It is made up by 33 004 images with complete annotations including relative pose, region of interest, image segmentation, and wireframe model detection. The dataset is published and publicly accessible on Zenodo split in 3 different datasets that can be used independently or combined: *Tango Spacecraft Dataset for Monocular Pose Estimation*, doi: 10.5281/zenodo.6499007, *Tango Spacecraft Dataset for Region of Interest Estimation and Semantic Segmentation*, doi: 10.5281/zenodo.6507863, *Tango Spacecraft Wireframe Dataset Model for Line Segments Detection*, doi: 10.5281/zenodo.6372848 (concept, supervision).

Autonomous trajectory optimization: design of light optimization algorithms for onboard autonomous guidance of spacecraft. Numerical optimization routines for real time, autonomous trajectory optimization and hazard detection and avoidance systems, based on semi-analytical methods in the scenarios of planetary landing, on orbit servicing, close proximity maneuvering around small celestial bodies, atmospheric entry, descent, and landing.

Experimental facilities management: development, implementation and managing of experimental facilities for testing of Guidance, Navigation, and control systems.

- Advanced Robotics and GNC Optical-based Simulator (ARGOS): analog facility devoted to test space borne vision-based navigation systems in scaled environment with realistic, controlled light conditions, in the scenarios of lunar/planetary landing, and close proximity maneuvers around small celestial bodies and cooperative/uncooperative spacecraft (concept, design, and implementation).
- SatLeash: microgravity experiment aimed to study the dynamics of ultra flexible elements in space (space tethers) and to test possible control strategies. Flown in the 65th ESA Parabolic Flight Campaign (concept, design, implementation, and operation of the system OBDH and sensors acquisition chain, distributed and synchronized across the docking base and 2 independent free floating elements).

System Engineering: Concurrent development of small space missions; Model Based System Engineering; development of new methods and tools to automatize and track the SE process.

- VERIDICA: software suite devoted to automatize the development and tracking of system requirements, test planning and execution, and verification activities, with automatic reporting and code generation (concept, algorithms and code development) used for internal management of large projects (i.e. *HERMES*).

13.2   Analytical skills

Very good analytical skills in modeling, analysis, synthesis, optimization, and validation of dynamic and control of linear and non-linear systems.

13.3   Computer skills

- *Operating systems*   Linux, Windows.
- *Programming languages* Python, Matlab, Julia, C/C++.
- *Office suites*   LaTeX, Libre Office, MS Office.
- *Other software*   Simulink, STK, structural analysis SW (Femap, MSC Nastran), 3D CAD modeling SW (SolidEdge, SolidWorks, Inventor).

13.4   Organizational skills

Experience in group managing, I coordinated groups up to 16 people in student and industrial projects. I managed legal and financial aspects of research projects, supported by the university administrative team. I supervised undergraduate and PhD students in their research.

13.5   Collaboration skills

Very good team spirit oriented to problem solving, my research experience got me used to work in groups, but also autonomously. I'm used to work in international environment, and to collaborate with multidisciplinary teams.

13.6   Languages

- *English*   Fluent (Speaking, reading, and writing).
- *Italian*   Native language.