



PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 41st cycle

**THEMATIC Research Field: NEUROMORPHIC PERCEPTION FOR ONBOARD SPACE
SITUATIONAL AWARENESS AND AUTONOMOUS SPACECRAFT NAVIGATION**

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 increasing overpopulation of satellites in Earth orbit calls for decisive measures to ensure the long-term safety and sustainability of space operations. A major challenge arises from the fact that only a small fraction of orbiting objects are active cooperative satellites, while the vast majority are uncooperative debris, ranging from defunct spacecraft and rocket bodies to countless smaller fragments. This growing population of space debris significantly heightens the risk of collisions and, if left unmitigated, could compromise the future usability of near-Earth space. In this context, reliable detection, tracking, and characterization of resident space objects (both cooperative and non-cooperative) are essential. These capabilities are fundamental not only for accurate trajectory prediction and collision avoidance but also for enabling autonomous proximity operations, such as active debris removal, in-orbit inspection, and satellite servicing. This research aims to advance these critical functions by developing and experimentally validating, through a working prototype, a novel onboard sensor suite capable of operating across both far- and close-range scenarios. The system is designed to provide seamless debris detection, tracking, and relative navigation, supporting all mission phases from long-distance approach to final capture or servicing maneuvers. At the core of this sensor suite is the integration of neuromorphic cameras, a disruptive sensing technology inspired by biological vision. Unlike conventional frame-based cameras, neuromorphic



	sensors asynchronously record illumination changes at microsecond latency and extremely high dynamic range. These characteristics make them particularly well-suited for detecting and tracking fast-moving or dimly lit debris, where traditional sensors often fail due to motion blur, overexposure, or limited temporal resolution. The resulting event-based data stream enables highly efficient onboard processing, reducing computational load and enhancing real-time responsiveness, key features for autonomous spacecraft navigation in dynamic orbital environments. This effort aims to demonstrate the transformative potential of neuromorphic vision in space applications, paving the way for next-generation onboard perception systems capable of safer and more autonomous operations in increasingly crowded orbital regimes.
Methods and techniques that will be developed and used to carry out the research	The research will begin with a comprehensive state-of-the-art analysis on the use of neuromorphic cameras in space applications. This review will assess the technological maturity of current solutions and identify the existing gaps that the proposed work aims to address, providing a rationale for the selection and procurement of the most suitable sensor hardware for experimental development. Subsequent efforts will focus on low-level data processing specifically tailored to the asynchronous and sparse nature of neuromorphic outputs. Dedicated processing pipelines will be designed for event aggregation and encoding, transforming raw event streams into structured representations that preserve temporal and spatial structures while ensuring compatibility with advanced neural architectures, such as transformer-based and spiking neural networks. To support these developments, datasets will be generated using laboratory setups with realistic satellite mock-ups and neuromorphic sensors. All datasets will be made publicly available to promote open science and reproducibility. Building upon these foundations, the research will investigate the application of neuromorphic sensing in space surveillance and tracking. The system will be developed to detect and track orbital debris, and to perform initial orbit determination based on event-driven data. The development of a dedicated simulator will



	accompany this activity, enabling the generation of representative event streams specific to such scenarios. In parallel, the processed event information will be exploited to design high-level relative navigation algorithms for operations in both long- and close-range regimes. Long-range capabilities will exploit line-of-sight measurements to support relative state estimation, while close-range algorithms will focus on complete relative pose estimation. Together, these activities enable autonomous approach, rendezvous, and servicing operations. This work will be complemented by a specialized simulator for synthetic dataset generation and validation against real experimental data collected in the facility. Finally, all developed algorithms will be integrated into the selected hardware platform and validated within a representative laboratory environment, such as a flatsat setup. This phase will provide the experimental demonstration of the complete sensing suite, assessing its performance, robustness, and real-time capabilities under realistic operational conditions.
Educational objectives	This PhD research is embedded within a broader European portfolio of projects aimed at strengthening the sustainability and resilience of the EU's space infrastructure. Within this context, the candidates will have the opportunity to interact with academic, industrial, and regulatory stakeholders, gaining exposure to multidisciplinary research environments. Regular participation in project meetings and presentations to the European Commission and partner institutions will foster the development of both technical and soft skills, including scientific writing, effective communication, and dissemination of research outcomes at different institutional levels. From a technical perspective, the candidates will acquire in-depth expertise in advanced sensing technologies and data processing methods based on state-of-the-art neural network architectures. This knowledge will be complemented by a strong foundation in estimation techniques, numerical methods, mathematical modeling, and computer programming, ensuring a comprehensive technical profile. The experimental component of the project will provide



	valuable hands-on experience in hardware integration and testing, offering direct engagement with sensor setup, calibration, and performance assessment in laboratory environments. Such activities will consolidate the candidates' ability to translate theoretical models into validated experimental results. Furthermore, the literature review and continuous engagement with current research will strengthen the candidate's skills in bibliographic search, critical analysis, and synthesis of scientific information. Participation in research group activities, including progress meetings, report writing, and collaborative discussions, will cultivate a professional research attitude and the ability to work effectively within interdisciplinary teams. Through this combination of theoretical, technical, and professional training, the PhD programme will form highly qualified researchers capable of contributing to ongoing and future space-related initiatives, and of advancing the technological competitiveness and sustainability of the European space sector.
Job opportunities	The program is supported by funding from an the EIC project AstrAware and conducted within the framework of an international research consortium. The main project also foresees continuous collaboration with other initiatives in the EIC Space portfolio, fostering a rich environment for knowledge exchange and cross-disciplinary innovation. This setting offers the candidates valuable opportunities for direct collaboration with industry partners, providing firsthand exposure to the professional landscape of the European space sector and its emerging technological trends. Moreover, the activities of the project funding this research already foresee several exploitation activities of the intellectual property generated within the project, including the possible creation of a startup. The candidates will be positioned at the forefront of algorithmic development for neuromorphic cameras in space applications (a field that remains largely unexplored) thus acquiring a unique and highly specialized expertise that will place them among the most qualified professionals worldwide in this domain. Furthermore, the research is embedded within the



	broader ecosystem of European projects dedicated to space traffic management and in-orbit servicing operations, ensuring strong alignment with current strategic priorities at both institutional and industrial levels. By the end of the program, the candidates will have developed comprehensive technical competence and interdisciplinary skills essential to address the growing challenges of sustainable and autonomous space operations, positioning them for a successful and impactful career in the rapidly evolving space sector.
Composition of the research group	0 Full Professors 2 Associated Professors 2 Assistant Professors 16 PhD Students
Name of the research directors	Michele Maestrini

Contacts
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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	1

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.