POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

THEMATIC Research Field: GUIDANCE STRATEGY FOR AUTONOMOUS PROXIMITY OPERATIONS ON GEOSTATIONARY TRANSFER ORBITS

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	GEO Satellite operators have traditionally chosen to opt for a GTO deployment, raising their orbit using an onboard propulsion system. This orbit-raising system is generally heavy (20 % of the mass) and used only once in the lifetime of the satellite despite representing 10 % of its costs. Recent market trends have shifted towards smaller GEO satellite platforms driven by several technological and commercial advantages. This small segment of GEO platforms offers greater flexibility in terms of development and deployment, improved time to market, and significantly lower capital expenditures compared to traditional GEO platforms. However, many of the small GEO platforms presently under development lack the capability to hold enough fuel to raise their orbit, and even if they could, it would take more than eight months to achieve orbit raising using electric propulsion. This exposes the satellite platform to an extended period in the Van Allen belts, known for high radiation levels that can potentially damage the satellite. As a result, access to the GEO orbit through Reusable and Refuellable Orbit Transfer Vehicles is becoming increasingly crucial. Orbit Transfer Vehicles (OTVs) will enable more efficient use of satellites by allowing operators to adjust their orbit to match their mission requirements. By eliminating the need for dedicated launch vehicles for each satellite, OTVs can enable faster and more cost-effective transfer of assets between GTO and GEO, increasing the overall efficiency and sustainability of space operations. OTVs on GTO will

	need to be able to perform proximity operations for rendezvous, docking and refuelling, on high elliptical orbits (like GTO), which require the development of dedicated manoeuvring and guidance strategies to tackle the highly nonlinear dynamics involved in relative motion on elliptical orbits. In order to increase the robustness of the guidance solution, the envisioned architecture can foresee an internal control loop capable of quickly reacting to system uncertainties and environmental disturbances, and an external guidance loop dealing with an eventual replanning phase needed to adapt the guidance trajectory.
Methods and techniques that will be developed and used to carry out the research	The activity will start with a review of the current approaches to the solution of the guidance problem for proximity operation around cooperative targets. In parallel, a preliminary mission analysis for the rendezvous phases on GTO will be performed, focusing also on the dynamics modelling framework most suitable for both the manoeuvring identification and guidance problem. The activity will proceed with the study of the guidance problem, with the introduction of an adaptive guidance architecture, tightly interconnected with the navigation function. The guidance module will be detached from the AOCS and constitute an outer loop capable of reacting to system uncertainties and environmental disturbances to adapt the guidance solution online based on the latest available measurements. The information on the expected illumination conditions of the target can be included in the guidance algorithm in order to approach the target considering operational constraints such as pointing the target without including the sun in the navigation sensor FOV or the execution of manoeuvres while not in eclipse.
Educational objectives	The main educational objectives are: - the acquisition of a solid background in cutting-edge methodologies for the guidance of satellites in the proximity of cooperative targets; - the development of skills in advanced numerical methods, software engineering and data-analytics techniques; - the development of key capabilities in the fervent area of GNC for proximity operations (docking, refuelling, inspection, active debris removal, on-orbit

	service, etc.).
Job opportunities	The research will be developed in the framework of a Horizon Europe Research Project: GEORyder: Giving Back Access to the GEO Orbit Through a Reusable Kickstage Vehicle Allowing Transfer from GTO to GEO. The project sees the participation of partners involved both in the design of OTVs and in small GEO platforms. This will offer networking opportunities for the candidate in the industrial sector which may better exploit the research results and that will need the long-term support of experienced professionals in the field.
Composition of the research group	0 Full Professors 2 Associated Professors 2 Assistant Professors 12 PhD Students
Name of the research directors	Prof. Mauro Massari

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	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.