



PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 38th cycle

PNRR_352 Research Field: NUCLEAR ENERGY SYSTEMS FOR SPACE APPLICATIONS

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

Space activities, devoted to the exploration of planets (e.g. Mars), satellites (e.g. Moon) as well as asteroids and the deep space, also in light of their possible exploitation, represent both a formidable challenge and a tremendous boost for innovation.

Innovation and competitiveness of companies, industrial /educational /research systems and Countries are historically some of the key motivations and objectives of all the initiatives related to space.

Moreover, in the recent period, the goal of the exploitation of resources has joined the knowledge one. Indeed, the world commitment in limiting the effects of the climate change is pushing the development and huge deployment of renewable energy and the corresponding energy storage systems (i.e. the ecologic transition) in the coming future.

The rare earths and other critical materials needed to sustain such a green revolution, as well as the digital one, are potentially at risk: both in terms of needed quantities and costs and strategic/geo-politic dependencies.

Therefore, USA (NASA) and other countries and space agencies are conceiving solutions able to reach, drill, manufacture and transport materials and products from asteroids.

Without any doubt, nuclear energy-based solutions are going to play a key role in all the exploration and exploitation endeavours, because of their power density



	<p>and reliability. USA, Russia, China are today leaders in such an R&D and technological challenge.</p> <p>Europe is playing the game, e.g. in the frame of the ARTEMIS mission to the Moon, and Thales Alenia Space-Italia is a leader and key player, bearing the responsibility of developing and providing modules for the International Space Station and of conceiving the project of the Moon surface station.</p> <p>The energy supply system for the future Moon station, devices, rovers, and experiments is of direct and paramount interest for the company. The investigation of Micro-Modular nuclear Reactors (MMR) and possibly Radioisotope Power Generators (RPG), able to provide reliable power for long periods and to operate in a suitable, integrated, satellite energy system, is the main objective of the research.</p> <p>The motivation and objective of the research can be fully considered in line with the topics targeted by DM n.352 (09/04/2022), Art.s 1.7 ("<i>missions</i>") and 6.4a ("<i>companies' innovation needs</i>"). PNRR: Mission#2C2 and Mission#4C2.</p> <p>In particular, according to EU Regulation 2021/241 (at the basis of PNRR), the R&D activity proposed is compliant with Art.3-Scope, item (c), related to "competitiveness, research, development and innovation", and will Art.4-General and specific objectives, par.1, related to "fostering high quality employment creation, and contributing to the strategic autonomy of the Union" (on space exploration and exploitation).</p> <p>The PhD student will spend at least 6 months at Thales Alenia Space-Italia.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The investigation will be mainly focused on the most promising MMR concepts: the Heat Pipe Reactor (HPR) and the Molten Salt Reactor (MSR).</p> <p>A holistic approach will be adopted, to address neutronic, thermalhydraulic, thermalmechanic, system and economic features. Safety and safeguards will be addressed as well.</p> <p>All the main reactor systems will be addressed: core and fuel, heat transfer, power conversion, heat rejection, control, maintenance, as well as the coupling with the Moon station energy system.</p>



	<p>The methods and techniques to be used will be mainly of numerical-modelling type. Among the state-of-the-art simulation codes: RELAP (safety), SERPENT (neutronics), OpenFOAM (fluid dynamics and thermal mechanics), FLUENT (CFD), MODELICA (object oriented modelling), COMSOL (Multiphysics), Matlab-Simulink (model predictive control). In-house models will be developed as well (e.g. for the economic analysis).</p>
<p>Educational objectives</p>	<p>The PhD candidate will develop an interdisciplinary approach: devoted to address not only the key features of the reactor system (from neutronics to economics), but also the integration of the MMR into the energy system of the Moon station (e.g. power storage systems, wireless energy transmission systems, other energy generators, energy loads).</p> <p>For this reason, all the PhD candidates involved on space application R&D topics and co-funded by Thales Alenia Space-Italia, will form the ‘Energy for Space’ working group.</p> <p>Moreover, a common educational path on the main requirements and features of space applications on planets and satellites, will be designed and developed together with Thales Alenia Space-Italia and the involved PhD programmes. Team working and problem solving capabilities will be as well key educational objectives.</p>
<p>Job opportunities</p>	<p>The emerging candidate’s profile will be highly attractive both in the research environment, where cross-disciplinary skills are more and more appreciated, and in the expanding field of space applications design, analysis, and management.</p> <p>Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research: INSTITUT POLYTECHNIQUE DE GRENOBLE (FRA), ORANO CYCLE (FRA), TECHNISCHE UNIVERSITEIT DELFT (NL), Milano Multiphysics (ITA), EU Joint Research Center-Karlsruhe, International Atomic Energy Agency - IAEA (Vienna)</p>



Composition of the research group	1 Full Professors 2 Associated Professors 2 Assistant Professors 10 PhD Students
Name of the research directors	prof. Marco Ricotti

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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

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Thales Alenia Space - Italia, Strada Antica di Collegno, 253 - 10146 Torino
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	(azienda, centro di ricerca o università europee, da concordare con Thales Alenia Space-Italia; es. Orano-FRA, JRC Karlsruhe-GER, Univ. di Grenoble-FRA)
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>Educational activities: Financial aid per PhD student is available for purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences, instrumentations and computer, etc. The amount is about Euro 5700.</p> <p>Teaching assistantship: Availability of funding in recognition of supporting teaching activities by the PhD student. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.</p> <p>Computer availability: individual use.</p> <p>Desk availability: individual use. Accommodation in Politecnico's Residences (http://www.residenze.polimi.it) is available for PhD candidates; special rates will be applied to selected out-of-town candidates (detailed info in the call for application).</p> <p>Research period abroad: Our candidates are strongly encouraged (6 months minimum is</p>



mandatory) to spend a research period abroad, joining high-level, research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 euro/month- net amount).