AEROSPACE ENGINEERING

DIMEAS - Advanced methodologies for the design and analysis of the mechanisms of a Lunar pressurized rover

Funded By	Dipartimento DIMEAS
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Context of the research activity	The research focuses on advanced modelling and design methodologies for key mechanisms of the Lunar Pressurized Rover (LPR), including docking interfaces, locomotion systems, and powertrain architectures. The activity is carried out within the Space It Up project in collaboration with Thales Alenia Space (Torino), aiming at enabling future lunar surface mobility and pressurized operations.
	The PhD activity will be conducted within the Space It Up project and in close collaboration with Thales Alenia Space – Torino, with the objective of developing advanced methodologies for the modelling, design, and optimization of key mechanisms of the Lunar Pressurized Rover (LPR). As future surface exploration missions require sustained human presence on the Moon, the LPR plays a central role as a mobile pressurized habitat capable of transporting crew and scientific payloads across the lunar terrain. The design of its mechanisms, e.g. docking, locomotion, and powertrain, is therefore critical to ensure safety, operability, reliability, and mission flexibility in extreme environmental conditions. The research activity will focus on three tightly coupled subsystems: 1. Docking mechanisms for lunar infrastructures The LPR must interface with multiple lunar surface assets, including pressurized habitats, logistics modules, and external workstations. The research will investigate: * modelling of docking and berthing systems under vacuum, dust contamination, misalignment, and thermal cycling; * mechanical requirements for pressure-tight interfaces; * guidance and alignment strategies for soft or semi-autonomous docking; * structural assessment of contact loads during docking and berthing operations. 2. Locomotion and mobility system for challenging lunar terrains

Objectives	The locomotion subsystem of the LPR must ensure reliable movement on regolith, slopes, craters, and rough terrains. The research will address: * modelling of wheel-regolith interaction and granular terrain mechanics; * optimization of wheel geometry, traction systems, and suspension architectures; * assessment of mobility performance under reduced gravity; * evaluation of dust effects, thermal constraints, and structural loads on the locomotion components. 3. Powertrain architectures and performance in lunar environment Reliable power generation, distribution, and storage are essential for crewed rover operations. The research will analyse: * powertrain concepts for continuous mobility and docking operations; * integration of powertrain and locomotion performance models; * optimization of energy consumption under operational mission profiles. Methodological approach The PhD work will adopt a combination of: * advanced multi-physics and structural modelling (docking contact dynamics, mobility loads, thermo-mechanical effects); * numerical simulation of subsystems and full-system operation; * optimization techniques for mechanism design; * validation through use cases and functional requirements provided by Thales Alenia Space.

Skills and competencies for the development of the activity	Background in mechanical or aerospace engineering, with knowledge of structural mechanics, mechanism design, and system modelling. Familiarity with mobility systems, multibody dynamics, or powertrain design is an asset. Programming (Python/MATLAB) and interest in space engineering and lunar exploration are strongly desirable.