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TOWARDS THE MOON AND BEYOND: PREPARING FOR THE FUTURE OF CISLUNAR AND SOLAR SYSTEM EXPLORATION

Abstract

A new era of space exploration has begun, as the Artemis program marks a fundamental step for human spaceflight. All eyes are on the Moon: NASA has recently proposed a Lunar Orbital Platform gateway concept as the basis for future space exploration. The Moon and the cislunar environment will serve as training grounds for extraterrestrial settlements, hosting the next developments of the space industry. Such ambitious objectives require a dedicated framework of innovative methods and operational strategies. Researchers of the Space Advanced Concepts Laboratory (SaCLaB) at the Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO) develop state of the art tools and methodologies to push the limits of cislunar exploration. To prepare for tomorrow, one must strive for innovation at all stages of mission design: this paper discusses the vision of the SaCLaB about access to the cislunar environment and to the Moon, in-orbit operations and exploitation of lunar resources. Rethinking our journey to the Moon and beyond is an essential part of the equation. Natural properties of multi-body dynamics create low-energy transport pathways to our natural satellite and further regions of the solar system. Near Rectilinear Halo orbits, future hosts of the Gateway, have stability and accessibility properties suited for human presence and staging missions, but they require dedicated system dynamics methodologies for mission analysis and operational purposes. Low-thrust propulsion will play a major role to ensure more sustainable mission profiles for cargo, maintenance and resupplying missions to lunar settlements. In-orbit operations and servicing are essential for repeated lunar access and surface exploration. Rendezvous and Docking operations are paramount for assembly, servicing and crew/cargo exchange activities. Station-keeping and orbit maintenance in Lagrangian point Orbits are also challenges to be overcome for extended human presence in the region. Multi-body dynamics theory and autonomous guidance and control systems can ensure that such operations are optimized in terms of fuel consumption and duration, while complying with the safety requirements and standards of tomorrow. Repeated access to the lunar surface requires new transfer vehicles and modules dedicated to transporting crew and cargo between lunar settlements and lunar orbits. Such systems will benefit greatly from recent advances in multidisciplinary optimization and reusability studies. Finally, lunar surface operations, logistics for ISRU, energy management and life support systems are presented as building blocks for a future lunar settlement.