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Human Exploration of the Moon and Cislunar Space (1)

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A SUSTAINABLE BRIDGE BETWEEN LOW EARTH ORBITS AND CISLUNAR INFRASTRUCTURES: THE LUNAR SPACE TUG

Abstract

The International Space Station (ISS) is the first space human outpost and over the last 15 years, it has represented a peculiar environment where science, technology and human innovation converge together in a unique microgravity and space research laboratory. However, the ISS retirement deadline is getting close and the entire space community is starting planning how the human exploration could move further, focusing on beyond Low-Earth-Orbit (LEO) missions. According to the Global Exploration Roadmap, the Moon represents one of the feasible pathways for advances in human exploration, as first step towards the final goal, Mars. Based on the experience of the ISS, one of the most widespread ideas is to develop a Cislunar Station in preparation of long duration missions in a deep space environment. Cislunar space is defined as the area of deep space under the influence of Earth-Moon system, including a set of special orbits, e.g. Earth-Moon Libration points (EML) and Lunar Retrograde Orbit (LRO). This habitat represents a suitable environment for demonstrating and testing technologies and capabilities in deep space. In order to achieve this goal, there are several crucial systems and technologies, in particular related to transportation and launch systems. The Orion Multi-Purpose Crew Vehicle (MPCV) is a reusable transportation capsule designed to provide crew transportation in deep space missions, whereas NASA is developing the Space Launch System (SLS), the most powerful rocket ever built, which could provide the necessary heavy-lift launch capability to support the same kind of missions. These innovations would allow quite-fast transfers from Earth to the Cislunar Station and vice versa, both for manned and unmanned missions. However, taking into account the whole Concept of Operations for both the growth and sustainability of the Cislunar Space Station, the Lunar Space Tug (LST) can be considered as an additional, new and fundamental element for the mission architecture. The Lunar Space Tug represents an alternative to the SLS scenario, especially for what concerns all unmanned or logistic missions (e.g. cargo transfer, on orbit assembly, samples return), from LEO to Cislunar space. The paper focuses on the mission analysis and conceptual design of the Lunar Space Tug to support the growth and sustainment of the Cislunar Station. Particular attention is dedicated to interface requirements between the Space Tug and the modules of the Station, whose design can be deeply affected by the Space Tug. Main results are presented and discussed, and main conclusions are drawn.