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Strategies & Architectures as the Framework for Future Building Blocks in Space Exploration and Development (1)

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VALUE-CHAIN ANALYSIS OF IN-SPACE SEGMENTS OF A CISLUNAR ARCHITECTURE

Abstract

Establishing sustainable lunar presence is the primary goal of multiple ongoing international programs like NASA's Artemis, ESA's Moon Village initiative, Russian-Chinese Joint Lunar research station et al. In order to create and support a sustainable Lunar presence, continuous and regular Cislunar operations would be required. A highly evolved Cislunar space architecture would be required to obtain this goal. A Space Architecture is combination of multiple elements or segments that make an entire mission. A Cislunar space architecture with the goal to support a lunar colony would require development of numerous systems and technologies. In this context, the mentioned Cislunar architecture would be one of the most complex form of system-of-systems. This Cislunar architecture can be broken down in three major segments based on the operational domain: 1) Earth-bound; 2) Cislunar space and 3) Moon-bound. The current study focusses on Cislunar space segments (i.e., mission architecture elements that operate in cislunar space). A live example of this segment is the Gateway element of the Artemis program which is a crucial outpost component that orbits around the lunar surface and does not operate on Earth or the Moon. This paper implements a generalist approach and identifies major categories of applications that fall under the in-space segment of a cislunar architecture. The application categories considered are debris management, transportation, stations depot, in-orbit servicing, and in-space manufacturing. Based on these applications multiple case-studies are identified for each category. The case-studies are past and ongoing concept studies, projects, and commercial endeavors that are targeting to develop required systems or technologies towards each application. These case-studies are examined in detail and used to conduct a value-chain analysis for each category. Factors associated with primary activities and support activities of a classical value chain analysis are addressed using the case-studies to draw final results. The goal of this study is to support ongoing efforts to recognize major driving factors and critical bottlenecks in each application category of the in-space segment of a cislunar architecture. The results from this study could be utilized to support research and decision-making processes at the highest-level and accelerate the innovation drive for Cislunar mission planning. The study could be potentially complemented with further steps to include Technological readiness Level (TRL) and recognize market trends.