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Author: Mr. Paolo Mangili
University of Houston, United States, paolo.mangili.97@gmail.com

SPACE TUGS AND LAGRANGE POINTS: KEY ARCHITECTURES FOR THE NEW CIS-LUNAR ECONOMY

Abstract

The question of technical and economic sustainability is central to make the space effort profitable. This paper deals with the issue of leveraging Lagrange Points in Cis-Lunar space as a natural infrastructure, making such locations the possible pivots of the New Space Economy. Working with Orbital Mechanics, specifically the Rocket Equation and Payload Fractions, we envision a small vehicle capable of reliably and routinely moving fuel and other utilities from the Moon to Lagrange Point No. 1, therefore establishing a fuel depot there. The convenience of this Space Architecture, as it'll be shown, lies both on the customer's and the operators' side: for the latter, it's more convenient to move Moon-mined resources from the Moon to L1, rather than from the Earth to space in general, due to the considerably higher Payload Fraction and lower Delta-Vs involved: it'll be demonstrated that to move the same mass of propellant from the Earth a rocket would need an amount of fuel at least an order of magnitude bigger than the Moon-based counterpart. This has detrimental effects on the flight pace, therefore the achievable time schedule and finally costs, as opposed to Moon-based activities. For customers working in Cis-Lunar Space, refueling at L1 is a convenient choice: instead of being forced to get to the Moon for refueling of Liquid Oxygen and Hydrogen for instance, coming to L1 enables a considerable discount in terms of propellant otherwise used to get to and from the Moon, a burden that will rest on the shoulders of the operators of the system described in the paper. This system consists of a relatively small space-borne vehicle, called the Space Tug, used primarily to move propellant from the Moon to L1, where a notional fuel depot could be established, but also adaptable to a whole series of activities in Cis-Lunar Space. From an Architectural perspective, the shift is made from traditional, one-off, bespoken missions, to a modular, scalable, repeatable, iterative and circular design, an approach already proven by the most successful private space businesses. The Historical and Technical analysis of this modus operandi, compared with NASA's programs over the decades, will show how this Space Architecture is potentially suitable for the purposes of the on-going Commercial Space Race.