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IN-ORBIT REFUELING. TECHNICAL AND ECONOMIC FEASIBILITY OF MOON-MINED PROPELLANTS' TRANSPORTATION, STORAGE AND DISTRIBUTION SYSTEMS

Abstract

The present paper analyzes the technical feasibility and economic sustainability of Moon-mined propellants' transportation, storage and distribution to final users. It considers first different technical options for propellant distribution and storage namely, the Heavy Lift (HL) and Orbiting Depot (OD) architectures. In the former, propellant is launched from Moon's surface to end-users via a single tanker, performing a rendez-vous and docking with on-orbit spacecraft. In the latter, tankers transfer propellant from the surface of the Moon to an orbiting depot which is reachable by various types of spacecraft for refueling. Both architectures are evaluated in terms of technical feasibility and performances, identifying the OD option as the most promising solution. The depot's optimal placement is then tackled, taking into account various option (LEO, Moon's orbit, Earth-Moon Lagrangian points) to identify the best solution with respect to different parameters as the depot's reachability, storage capability, operating windows, etc. This part will also estimate the engineering costs of the OD solution. Second, the paper addresses the economic sustainability of the OD option in a market composed by a mining company, a transporter/distributor

company, and end-users. Pricing strategies of these companies are interdependent. The total demand of propellant to be addressed by the mining company (Qm) results from the sum of that coming from the transportation/distributor company (Qt) plus the demand of the final users (Qu). The latter, in particular, will largely depend on the benefits granted to space missions by on-orbit refueling. The price set by the transportation/distributor company (Pt) hinges on the price of substitute products (PE) as propellants sent to various orbits from Earth, which constitute a benchmark for the market. Based on the above assumptions, the paper calculates the net present value (NPV) of the transporter/distributor company. From a financial standpoint, an investment with positive NPV is worth making since it will create value. As the estimates of investment, operational costs and revenues are highly uncertain, a risk model evaluates the exposure of the ventures to factors that could lower their profits and lead them to fail. This paper constitutes an extension of a prior study by Sommariva et al. [Acta Astronautica 170 (2020)], which focused on the economic sustainability of producing propellant (hydrogen and oxygen) on the Moon.