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COMPREHENSIVE STUDY OF SMALL SATELLITE MOON MISSIONS: ARCHITECTURE DESIGN, ELECTRIC PROPULSION SYSTEM OPTIMIZATION AND COST ANALYSIS

Abstract

This paper demonstrates the improved comprehensive study “Electric Propulsion Optimization for Microsatellite Moon Missions” which was presented at the IAC2014. The previous study showed that spacecraft takes a minimum mass at very low thrust levels. As thrust levels increase, the minimum mass value seems just as an outcome; it wasn’t optimized anymore.Our practical problem was reduced to find thrust level due to the selected burn time. Therefore, we have approached the design by determining spacecraft volume. Various spacecraft architectures are demonstrated such as hexagonal and rectangular structures. The carbon fibre honeycomb or 6061 T6 Al materials are considered as the main structure. The total spacecraft mass is formed between 100 − 300 kg with up to 2kW total spacecraft power rather than the 50-80 kg and 200-400W scales of the previous research. The lay-outs of subsystems are illustrated via CATIA software.An overall value is selected between 10 and 25 meter square. The new propulsion optimization comprises thrust levels in the range of 8 - 52 mN. Increasing thrust levels result more convenient mission times. The xenon gas is the propellant that stored in spherical titanium or carbon-fiber tank. In addition, trajectory design has been accomplished by using low-thrust minimum-time transfer between non-coplanar circular orbits in the presence of Earth shadow. Furthermore, the trajectory design is simulated by Systems Tool Kit and General Mission Analysis Tool. Consideration of the Earth-shadow eclipse increases the accuracy of the result. Therefore, sunlight, umbra and penumbra durations of the proposed mission cases are calculated. Two orbit transfer cases are examined that (1) LEO-LLO and (2) GTO-LLO. Inclination changes are 37 deg and 62.5 deg for the LEO transfer case and 83 deg for the GEO transfer case. Delta-V values are over 7200 m/s for LEO case and over 3000 m/s for the GEO case. Finally, mission durations to reach the LLO are aimed maximum 1.5 years for LEO case and 0.5 year for GEO case. These two cases are significant to perform alternative cost analysis and mission time. Furthermore, we came up with a cost analysis by analogy of the previous Moon missions such as LADEE, Stardust, Lunar Prospector and Smart-1. Ultimately, the main objective of this paper is to create a standard infrastructure of small satellite Moon missions by using low-cost and reliable ion propulsion systems and additive manufacturing.