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ELECTRIC PROPULSION OPTIMIZATION OF MICROSATELLITE MOON MISSIONS: PRELIMINARY DESIGN APPLICATION ON CUBESATS AND TURKISH SMALL SATELLITE FIELD

Abstract

Cubesats have a special place in small satellite classification. Low cost manufacturing, frequent launch opportunities and fast production are the main advantages. Advancement of technologies for materials and propulsion systems provide new mission concepts for CubeSats. NASA's interplanetary advanced concept report is an important reference that shows some mission examples for 3U and 6U satellite designs with solar sail propulsion. In addition, there are some important inspiring CubeSat concepts for future applications: Pharmasat, Genesat and 3D Rampart. The next design step for small satellites is miniature thruster integration. An applicable miniature propulsion system might pave the way for interplanetary missions of CubeSats that can commence from Earth-Moon system destination. The literature indicates that miniature ion thrusters are more efficient and feasible for a 3Usat lunar mission than chemical propulsion. A sufficient navigation system, attitude determination and control system, power system and thermal production systems must be compatible each other. Gimbals must control both solar arrays and thrusters, the battery must be adequate on eclipse times and absorptivity and emissivity values of arrays must be considered. As part of this analysis (1) Orbit classification and sufficient orbit transfer selection, (2) Hohmann transfer analysis, (3) Low thrust with non-coplanar orbit analysis, (4) Low thrust with solar electric propulsion analysis, (5) Thermal subsystem calculation, (6) Structure design and mass budget estimation, (7) Power budget design and battery selection, (8) ADC sensor and board selection are provided. MATLAB is used for numerical analysis of orbit transfer. Gravitational effects of the Moon are not considered in the calculations. The budget and an implementation plan are estimated for a potential mission. The importance of MEMS and 3D printing are discussed for future mission predictions. Because of the low thrust, a 3Usat with miniature ion thruster cannot land on the moon. To overcome this problem, an external landing POD design is estimated. Analyses show that 3Usat lunar mission is possible with an ion thruster which has 30W power. Total required spacecraft mass is around 8 kg with 2.3 kg propellant mass. Total spacecraft required power is 80W with margins and contingencies. Numerical trajectory analyses present that required delta V is over 7000 m/s and low-thrust with solar electric propulsion transfer is the better option for mission.