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HUMAN MARS MISSIONS PERFORMED USING SOLAR ELECTRIC PROPULSION

Abstract

While solar electric propulsion (SEP) is being widely considered for cargo transport to Mars, its value for propelling fast human missions is often viewed as marginal. This conclusion is driven by the high electric power requirement (multi megawatts) of a fast, human spacecraft, coupled to the low power density of traditional solar arrays. However, recent progress in the field of thin film photovoltaic cells and large deployable structures may challenge this conclusion. The performance of any electrically propelled spacecraft depends mainly on the mass/power ratio of its power generator. We find that for a SEP Mars mission the reduction in solar illumination with the distance leads to a decrease of the overall performance of the spacecraft by approximately 15Our approach to a SEP Mars mission follows closely the split-sprint concept considered by NASA in its latest design reference architecture in which a robotic Mars cargo ship first prepositions a habitable infrastructure on the planet before the crew travels there in a faster and lighter ship. Two alternatives are considered: starting from a 500 km LEO chosen to reduce the aerodynamic drag on the solar arrays to an acceptable level, and from the Deep Space Gateway. While the second alternative may prove to be the more convenient of the two, the first allows a direct comparison with the missions described in the literature. In this paper, we present SEP for both the cargo and the crewed ship as a potential alternative, which could further reduce the in-space transit time without undue penalties in the initial mass in low Earth orbit (IMLEO). A SEP mission of this kind may well represent a near-term solution to bridge the technology gap between chemical propulsion and the long-term development of nuclear electric propulsion. Although we foresee that, ultimately, NEP systems will become the mainstay of fast human deep space transport, we examine the human SEP option as an attractive intermediate path on this journey. One that capitalizes on the rapid evolution of the solar array technology and supporting the early deployment of high power electric propulsion systems such as the VASIMR engine. We have investigated the challenges of building suitably large, lightweight, solar arrays to produce the electric power for both cargo and human spacecraft and present our conclusions regarding the advantages of such SEP architectures in the context of a long-stay human Mars mission.