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Systems and Infrastructures to Implement Future Building Blocks in Space Exploration and Development (2)

Author: Mr. Steffen Callsen
Bremen University of Applied Sciences, Germany, Steffen.Callsen@gmail.com

Prof. Uwe Apel
Hochschule Bremen, Germany, uapel@fbm.hs-bremen.de
Mr. Mathias Rohrbeck
OHB System AG-Bremen, Germany, mathias.rohrbeck@ohb.de
Mr. Ingo Gerth
OHB System AG, Germany, ingo.gerth@ohb.de
Mr. Luca Corpaccioli
OHB System AG, Germany, luca.corpaccioli@ohb.de

CONCEPTUAL DESIGN OF A HIGH-POWER SOLAR-ELECTRIC TRANSPORTATION SYSTEM FOR MARS EXPLORATION

Abstract

The support of crewed missions to Mars with cargo or by delivering observation/communication satellites to Mars orbit becomes an increasingly important topic with crewed missions on the horizon. Electric propulsion (EP) offers substantially higher specific impulses and therefore potential propellant savings. The usefulness of a stand-alone electric transportation system is investigated in this study with the focus on the propulsion and power subsystem. The mission is mainly constrained by an Ariane 6.4 launch into escape orbit and a maximum duration of 3.5 years to achieve a Mars orbit. Electric thruster technologies vary in a wide range regarding thrust and specific impulse. In general, Hall effect thrusters have higher thrust and lower specific impulse while gridded ion thrusters have lower thrust but achieve a significantly higher specific impulse. Due to the limited mission duration requirement, favouring high specific impulse gridded ion thrusters is not necessarily the apparent choice since the transfer to Mars can also be optimized for lower propellant expenditure with higher thrust levels, utilizing an extensive period for a coasting phase. Five system alternatives are traded to evaluate the impact of thrust magnitude, specific impulse and launch mass. For each system a mass assessment factoring in the mass of the thruster(s), power processing units, solar array and propellant is conducted. Aside from the propellant mass, the key mass driver is the solar array due to the high power demand of EP thrusters. It is foreseeable that a substantial improvement in power-to-mass ratio would significantly improve the payload mass. Initial results show that either a single 20 kW hall effect thruster or a cluster of seven 4.6 kW gridded ion thrusters delivers the highest possible payload mass. Additionally, launching with the lowest hyperbolic excess velocity and thereby highest launch mass possible is also found to be advantageous. A detailed system design based on one of the architecture baselines will be presented.