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ANALYSIS AND SYSTEM DESIGN OF NUCLEAR THERMAL ROCKET EMPLOYING PROPELLANT PRODUCED IN-SITU FOR PLANETARY EXPLORATION

Abstract

As envisioned by the Global Exploration Roadmap (GER), Moon permanent settlements and further expansion of humankind to Mars will be a reality in future years. This type of exploration missions will benefit from the utilisation of in situ resources gathered on extra-terrestrial planetary bodies. Therefore, a propulsion system that can efficiently exploit the propellant mixture produced in-situ will be useful. Moreover, interplanetary mission transit times could be reduced with an engine that can provide better performance than chemical rockets.

In this paper, the results of the study of Nuclear Thermal Rockets (NTR) employing Liquid OXygen (LOX), Liquid Hydrogen (LH2) and water as propellant are presented. This analysis starts from the second iteration on the LUnar Propellant Outpost (LUPO) mission, developed during the 11th SEEDS programme, in which the possibility of extracting water and producing both LOX and LH2 on Moon surface is explored. In-Situ resource production enables new scenarios where NTR can be exploited, reducing the mass at launch both in terms of propellant needed and dimension of the architecture. The theoretical possibility of producing the same resources also on Mars surface further decreases the dependency from Earth. Moreover, NTR are characterised by high performance in terms of thrust and specific impulse, which outperform chemical propulsion systems. NTR are thus a key technology for future human space exploration missions on Mars and beyond. The performance of these systems and their feasibility are analysed for different exploration scenarios that could be of interest in the near future, such as Moon Surface-Lunar Orbit and Moon-Mars transfers and a summary of the analysis is discussed.

The study is carried out by the 11th edition of the Specializing Master programme in SpacE Exploration and Development Systems (SEEDS) of 2018/19 at Politecnico di Torino (Italy). This work was performed in cooperation with students from ISAE (France) and University of Leicester (UK). The project is supported by Thales Alenia Space Italy, the European Space Agency (ESA), and the Italian Space Agency (ASI).